A COMPARATIVE STUDY OF THE EFFECTS OF ISOMETRIC TRAINING ON THE PHYSICAL FITNESS OF MALE YOUTH

By

MERRILL DWANE REDEMER

Bachelor of Arts
Panhandle A & M College
Goodwell, Oklahoma
1954

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1960

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Thesis Approved:

Thesis Adviser

Richard P. Jungers

Guy R. Donnell

Edwin E. Vineyard

Dean of the Graduate School

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CHAPTER I

INTRODUCTION

This is a report of comparative investigation designed to validate isometric exercises as a technique for developing physical fitness in male youth. To determine the effects of isometric effort as a training activity, an experimental sample of youth employed isometric training was compared with a comparable sample who followed a program of weight training in physical fitness. Weight training is considered to be an effective program for the development of physical fitness. Therefore, it constitutes a proven standard against which isometric training can be measured.

Need for the Study

Few educators would deny that the development of physical fitness is one of the primary objectives of physical education. However, attainment of this objective for all of the children in the schools of the nation has not yet been accomplished.

In spite of the high standard of living, relative freedom from disease, and healthy environments which characterize this country, the operational physical capacities of a large portion of the populace continue to be below the optimum for development and maintenance of organic health, physical attractiveness, mental efficiency, and for the preparedness for possible personal or national emergencies.

In most societies of the world the rigors of everyday living are sufficiently demanding to insure an operational level of physical fitness, but the evolving patterns of living in America have introduced habits for the typical citizen which are not conducive to a healthful level of physical fitness.

Some factors involved in these patterns are the increasing percentage of the work force engaged in sedentary occupations, a disproportionate caloric intake in comparison with caloric need, a resultantly high percentage of overweight persons, and the predominance of sedentary pastimes.

The increasing rate of heart ailments among all adult segments of the population and particularly among men in the early middle age range has caused an awareness of the need for activities which will lessen the incidence of such illnesses. The writer is aware that heart ailments are not a common concern of students in the secondary school, but adults tend to follow leisure time activities which are learned during the school years. (64)

Greater continuation of physical activities into adult life has been impeded by lack of available community facilities, knowledge, and skills which are appropriate only for the adolescent age, activities which require team participation, and by the number of activities which are appropriate only for specific seasons.

In summarizing the causes of heart ailments and emphasizing the importance of exericse to lessen the possibility of such personal catastrophe, Raab (67, p. 17) states:

> No one single factor, such as diet, emotional pressures or lack of physical exercise, can be made fully responsible

> for the present-day high incidence of functional and degenerate heart diseases; rather do their varying combinations become pathogenic through mutual aggravation.
>
> The inactivity-induced neurovegative imbalance is reversible by appropriate and persistent exercise training. With the necessary precautions, such training is applicable also to overt cardiac patients, and in particular, to those seemingly healthy, yet quietly degenerating sedentary adults, for whose benefit the establishment of organized mass-reconditioning centers and programs, like those already existing in other countries, is being urged.

The same lack of physical exercise and resultant physical fitness deficiencies was of major concern to Bortz (9, p. 9) in an attempt to correlate anxiety and physical inactivity. He concludes:

> With reduction in work and greater leisure time there is appearing an increase in tension and neurotic states. Widespread use of tranquillizing drugs is not the answer.

Additional cause for concern was brought before the American public when a comparison of the physical fitness of 4264 students, six to sixteen years of age, was made with the fitness levels of their counterparts in Austria, Italy, and Switzerland, using the Kraus-Weber Fitness Test for the basis of their comparisons.

This comparison showed that 57.9 per cent failed the test in the United States while 8.8 per cent of the Swiss, 8 per cent of the Italians, and 9.5 per cent of the Austrians failed.

In a subsequent article which expounds on the implications of these findings, Kraus and Hirshland (40) conclude:

> We have the impression that insufficient exercise may cause the dropping of muscle efficiency levels below that minimum necessary for daily living. The same lack of exercise may cause inadequate outlet for nervous tension.

> Lack of sufficient exercise, therefore, constitutes a serious deficiency comparable with vitamin deficiency. Prevention of this deficiency is an urgent need.

Perceiving these physical fitness deficiencies as a national problem, President Dwight D. Eisenhower formed the President's Council of Youth Fitness on September 6, 1956. This Council set out to determine the nature and extent of the physical fitness deficiencies as they related to the status of the American school child. In February of the following year the American Association for Health, Physical Education, and Recreation (AAHPER) Research Council was involved in planning and compiling the _AAHPER Youth Fitness Test_ and subsequently administered it to a selected sample of the population of school children in grades five through twelve.

From the results of this assessment, norms were derived and published in 1958. A revision of the norms and a test manual was published in 1961.

The President's Council on Youth Fitness in 1961 produced a volume entitled _Youth Physical Fitness: Suggested Elements of a School-Centered Program_ which made specific recommendations to the schools of the nation concerning ways of raising and maintaining the physical fitness levels of their students. Some of these recommendations involve more time, facilities, and supervisory personnel than that which is available in many of the schools. For these schools, an expedient, inexpensive, and effective technique of developing physical fitness is needed.

Research findings from experimentation which weight training programs (the most common type of progressive resistance) indicate strongly that weight training will develop strength, speed, endurance, and agility in a very short period of time. Although this activity has proven successful in fulfilling its intended purposes, universal acceptance has been retarded by numerous misconceptions (e.g., muscle-boundness, high incidence of injuries, narcissistic inclinations, etc.), expense of installing and maintaining the equipment, and the necessity of close supervision.

Isometric training, which is a relatively recent innovation in physical education technology, utilizes basically the same physiological principles as weight training when used as a progressive resistance routine. Isometric training denotes a routine of muscular contractions against a stationary object. To date, attempts to determine the net physiological effect of isometric effort have been somewhat inconclusive. (See Chapter III)

Therefore, an attempt to determine the effects of isometric training on physical fitness seems justifiable. If indeed this technique will develop some of the various attributes of physical fitness, strength, speed, endurance, and coordination, it will make a desirable level of fitness possible to many school children who have heretofore been denied this program in their school.

Since weight training programs have been supported by research findings as a means of developing the components of physical fitness, and since the physiological basis for isometric training is comparable to weight training, it seems only fitting that weight training be used in this study as a meaningful standard against which isometric activity can be measured.

Statement of the Problem

The purpose of this study was to determine the differential net effects of isometric and weight training as they relate to various attributes of physical fitness.

Tested Hypotheses

For the purpose of making a statistical comparison of the two progressive resistance techniques, the following hypotheses were tested:

1. The students who experience the isometric program will improve on performance of the *Youth Fitness Test* more than the students who experience the weight program ($p \leq .05$).

2. The students who experience the isometric program will increase more in body weight than will the students who experience the weight program ($p \leq .05$).

3. The students who experience the isometric program will continue the training beyond school more than the students who experience the weight program ($p \leq .05$).

Pertinent Assumptions

The design and implications of this study are contingent upon the viability of the following assumptions:

1. Physical performance as measured by the *Youth Fitness Test* is an index of physical fitness.

2. Maturation, adequacy of diet, and motivation had no differential effect on either training group.

3. Responses of subjects on the follow-up instrument reflected the actual impressions of the subjects.

Limitations of the Study

Since the experimental program involved the physical performance of growing males, some caution should be made in the generalization of the findings as they relate to females or mature males.

No attempt was made to dictate or determine caloric intake, living routines, or non-school activities (other than to request that no form of progressive resistance exercise be used beyond that required in school).

Motivation could not be determined for the subjects' pursuit of the training routine or performance on the tests. However, the interest of male adolescents is generally conducive to maximal effort on such tasks. Motivation should also have been increased by their knowing that they were to be compared with a group of their peers.

The effects of maturation were not treated in the study. It was assumed that this factor would have no differential effect on the groups involved.

Summary

In view of the increasing concern for higher standards of physical fitness and the frequent lack of resources and facilities necessary to alleviate this concern, schools and other agencies are challenged to discover more expedient means of developing and maintaining physical fitness.

This study represents an effort to validate an inexpensive, simple isometric training program by comparing it with a proven program of weight training.

In the next two chapters, the development of both training programs, previous research findings which involve either of these programs, the physiological rationale for their use, and the hypotheses which were tested are discussed.

Chapter IV describes the student sample, instruments used in the study, the experimental programs, and procedures used in the collection, and treatment of the data.

The last two chapters contain the findings of the experiment and recommendations based on those findings.

CHAPTER II

HISTORICAL DEVELOPMENT

This chapter presents a short review of the historical development and present status of isometric training and weight training as techniques of progressive resistance exercise.

A Brief History of Progressive Weight Training

The history of progressive resistance as a practice for physical development extends back to the earliest years of recorded history. Archeologist have found evidence of weight lifting in some form that existed in Egypt, Ireland, China, and Greece prior to the Christain Era.

Pictures on Egyptian tombs demonstrating strength development exercises have been dates at about 2500 B.C. (50, p. 14) The Chou dynasty (1122-249 B.C.) is reported to have used a person's ability to manipulate heavy weights as one test of military fitness. (87, p. 24)

Among evidence in early Greek history which indicates a strong interest in feats of weight lifting include heavy stones found at Olympia and Santorin bearing inscriptions of names of people who had lifted them and the dates of the feat which revealed that these activities took place during the sixth century B.C.

Massey et al., (50, p. 15) reported that the weights, called halteres, used in the Greek pentathlon were refined into systematic exercises:

> By the second century A.D., the swinging of halters had developed into a regular system of exercises with such movements as bending and straightening the arms, lunging with the arms extended as in boxing, and alternately bending and straightening the trunk. (50, p. 15)

This interest was gained largely through the writings of Seneca (4 B.C. - 65 A.D.) and Juvenal (65 A.D. - 128 A.D.). The result was considerable popularity of public gymnasia where many Romans pursued weight lifting activities. (50, p. 15) Galen, a noted Roman physician of that era, recommended a system of dumbbell exercises which are comparable to some being used today. (87, p. 93)

The Middle Ages seemed to obscure any references to weight training or weight lifting. With the Renaissance, the English appear to be the first to renew interest in such activities. Sir Thomas Elyot, (25, p. 75) writing in 1531, elaborated on means of living a better life by advising youth to practice weight training:

> . . . . laborynge with poyses made of leadde or other metall, called in latine Alteres, liftynge and throwyng the heuy stone or barre, playing at tenyse, and diuers semblable exercises. . . . . exhortyng them which do understande latine, and do desire to knowe the commodities of sondrye exercises, to resorte to the boke of Galene, of the gouernance of helth, called in latine De Sanitate Tuenda where they shal be in that mater abundantly satisfied, and finde in the readynge moche delectation; which boke is translated in to latine, wonderfull eloquently by doctor Linacre, late mooste worthy phisition to our mooste novle soueraigne lorde kynge Henry the VIII.

At Knole, England, a crude pulley apparatus was found which had facilitated weight lifting. This machine was estimated to have been used in the early seventeenth century. (50, p. 15)

Massey (50, p. 15) reports that weight lifting was practiced extensively in France and Germany during this period. He states:

> Joachim Camerarius, who taught at Nurembury, Tubingen, and the University of Leipsic, published in 1544 a brief dialogue on exercise in which he mentions the lifting of weights as one of the exercises which should be included in a model school. Two of the leading German physical educators of the early nineteenth century, Gutsmith and Jahn, advocated heavy resistance exercises as a means of body development. (50, p. 15)

Murray and Karpovich (62, p. 5) credit Germany and other Middle European countries with the rise and spread of weight lifting and feel that modern weight lifting derived from the activities of the strongmen who pursued weight lifting in these countries during the nineteenth century. Notable German strongmen of the time were Norman Schemansky, Joseph Steinbach, Karl Swaboda, Herman Goerner, Arthur Saxon, and George Hackenschmidt.

There is evidence that some of the early colonists exercised with weights, but there seems to be no record of this being a regular activity. Reference is made, however, to an excerpt from Benjamin Franklin's letter dated August 19, 1772 to his son in which he recommends using dumbbells as a means of better health:

> The dumb-bell is another exercise of the latter compendious kind. By the use of it I have in forty swings quickened my pulse . . . . . (88, pp. 405-06)

In the United States during the latter half of the nineteenth century, which Weiner (92, p. 3) calls the "Health Lift Era", weight training was rapidly becoming a carnival activity. Dr. George Winship Baker, a graduate of the Harvard Medical School, toured the United States and Canada delivering lectures and demonstrations on weight lifting. In addition to there tours, he sponsored the Winship Gymnasium in Boston and encouraged his disciples and others to believe that strength is health and health is strength.

Rice et al., (73, p. 191) summarized the effects of Winship's teaching by saying:

> It has taken physical education almost a century to live down this concept that developed from these strength seekers.

Winship stopped his travels in the 1870's but his influence on the public opinion of weight lifting prevailed. Such common impressions of the "strongman" laid an appropriate setting for more traveling strongmen to tour the continent and flaunt their strength. Most frequently mentioned strongmen of that era from this continent are Richard Pennel, Eugene Sandow, and Louis Cyr.

From Europe, Arthur Saxon, a German, and numerous other preformers traveled in the United States as professional showmen. Weiner (92, p. 3) obviously felt that this type activity dominated weight lifting, for he entitled this the "Professional Strong Man Era." (1890-1910)

Appropriately, Weiner (92, p. 3) entitles the next two decades as the "Mail Order Era" (1910-1929). Theodore Siebert in Germany and Edmund Desbonnet began selling programs via mail in their countries shortly after the turn of the century. In the United States, Alan Calvert formed the Milo Barbell Co. in 1903.

Calvert is also credited with inventing an adaptable barbell which could be made heavier by pouring lead shot into the hollow globes on the end. This innovation was soon made obsolete by his using plates of varying weights which could be removed from and replaced on the bar quite easily. (62, p. 13) He boosted the mail-order sales by writing numerous articles and a book on weight lifting and weight training and by developing sound techniques to aid the amateur. Some of his techniques are widely accepted today in weight training.

Weight lifting and weight training as an activity for the amateur began to flourish during the second decade of this century. Factors aiding this growth were: (1) weight lifting was added to the Olympic games in 1896, (2) availability of weights via mail, (3) recognition and acceptance of weight lifting by the Amateur Athletic Union in 1927, (4) training techniques and facilities became more reasonable and sophisticated, and (5) there was a steady growth of athletic clubs, private and public gymnasiums, Y.M.C.A.'s and educational institutions which sponsored weight lifting.

Following World War II, many of the common misconceptions held by the critics of progressive resistance exercise were refuted by: (1) the subjection of weight programs to research, (2) the successful use of weight training to supplement athletic programs, and (3) the use of weight training in physical therapy.

The therapeutic use of weight training has been accredited to Thomas DeLorme, an orthopedic surgeon, who was, as a member of the Army Medical Corps, responsible for physical rehabilitation of wounded soldiers. DeLorme, a former weight lifter at the University of Alabama, experimented with some of the techniques of weight training and found that they produced amazing therapeutic results. The military services rapidly incorporated DeLorme's newly discovered techniques into action. They have subsequently gained wide acceptance by physical therapists.

After World War II, grants from the Pope Foundation and the National Foundation for Infantile Paralysis, Inc., allowed DeLorme and Watkins to refine and research these techniques. The major results were published in 1951 in a volume entitled <u>Progressive Resistance Exericse Technic and Medical Application</u>, which has been hailed by Hellerbrandt: (69, p. 7)

> The recent demonstration of how much can be done to expedite the return of normal function by the systematic use of judiciously administered exercise, graded in dosage, is one of the important contributions of the period of human knowledge.

Much subsequent research has been done by physiologists and physical therapists since DeLorme's initial publication and the scope of such findings seems to be widening the use of these and other new techniques of progressive resistance exercises.

Bob Hoffman was reportedly the first to advocate weight training for athletic training. Hoffman, a Y.M.C.A. athlete, found that after working with weights for a period of time, he was more proficient with canoeing, rowing, and track and field. He later entered the barbell business and began publication of <u>Strength and Health</u>, a magazine through which he espoused the desirability of weight training for athletes. Since weight lifting and weight training were not accepted by athletic coaches and trainers, the empirically based recommendations of weight programs for athletes were not incorporated into athletic programs.

The earliest published reports on the use of weight training for building college athletes are dated in 1956. (65) Since then, the successful use of progressive resistance programs have become commonplace in professional athletic leagues as well as collegiate and secondary programs for baseball, basketball, football, track, field, swimming, and wrestling.

Pulp magazines which appealed to the narcissistic motivations of their readers were filled with success stories and empirical observations of techniques and principles for development. Generally these publications were designed to create new sales of weight sets and tended to exaggerate the results of weight training. Since they were written with this purpose in mind and had more appeal to the physical cults than the respectable reading public, their contentions were generally disregarded by the latter, e.g., Hoffman's advocacy of weight training for athletes as mentioned above.

Although Calvert's (1903), Hoffman's (1932), and many other such periodicals have been discontinued, one need only glance at any newsstand to see that magazines of this type still flourish.

It seems significant that the American Association for Health, Physical Education, and Recreation Research Quarterly published no account of research on the effects of weight training prior to Capen's article on May 1950. Since then, numerous research reports have been published by the Research Quarterly and other journals of reseach.

These initial reports involved physical attributes which were more meaningful to the field of athletics than to physical education, but the scope of such investigation has broadened to encompass areas of interest to other concerns of education.

Today weight training is being used extensively in athletic programs, health clubs, physical education curricula, and physical therapy.

Rasch and Freeman (72, p. 35) write of progressive resistance in 1954:

> Only rarely, however, do schools of physical education offer any instruction in its techniques and physiological aspects. As a result their graduates usually know comparatively little about the subject.

Evidently Rasch (69, p. 12) feels that wider acceptance is approaching, for only eight years later he writes:

> All indications are that the trend toward the use of weights by the feminine sex will continue, and it is conceivable

that at some future time weight training for both boys and girls will become a routine part of the high school and college physical education program.

A Brief History of Isometric Training

Seemingly, no record of any individual or group using isometric training for physical development exists before the twentieth century, and no complete record of its use during this century is available.

The first known advocate of isometric muscle contraction for size and strength was an immigrant named Angelo Siciliano. This man, under the glamorized American stage name of Charles Atlas, sold mail-order programs using "dynamic tension" to the American public. "Dynamic tension", as advocated by its users, involves contracting an ipsilateral limb against the contralateral limb or competing contractions of agonist muscles against antagonist muscles.

Whether the failure of the public to accept this technique which Atlas espoused can be attributed to the lack of explained physiological rationale or his exaggerated claims cannot be concluded from published information.

As early as 1928 an unpublished master's thesis entitled _A Study in Short Static Strength of Muscles_ was written at Springfield College. During the next two years, three other theses at the same academic level were written on static exercise. Like most dissertations, they seem to have been unheeded, unheralded, and unacclaimed. Years later (1946) Hellerbrandt (30, p. 399) suggested that strength could be implemented by isometric contraction:

> A muscle develops maximum tension when the load is so heavy that it is not allowed to shorten at all. Under these conditions the muscle maintains its optimum length for maximum energy production throughout the period of exertion.

Even this writing which appeared in the <u>Southern Medical Journal</u> attracted little attention. Not until almost a decade later was this exercise technique commanding major attention.

Isometric training gained considerable attention for the first time in 1953 with the publication of an article by Hettinger and Muller entitled "Muskelliestung and Musketraining." These two German Physiologists contended that a single two-thirds isometric contraction of six seconds duration each day would result in a weekly gain of five per cent of initial strength. They further contended that increases in effort, duration, or frequency of contraction made no faster gain. Hettinger and Muller further contended that the reason for such gain was the natural reaction of the muscle to the occlusion of oxygen.

Although physiologists have confessed that they really don't know what causes strength growth, several questioned the validity of this thesis. Resulting efforts to verify or refute their contention led to considerable disagreement which has not to date been finally decided. The point on which most reported research will agree is that isometric effort will cause significant strength gains.

Some rather unsubstantiated claims of the effects of isometric training are being made. Most of these unsupported claims arise from those who have an isometric kit or program to sell, for this recent innovation has stimulated keen competition for the isometric apparatus market. Some of the supposed effects mentioned are fewer injuries, loss of fat, better coordination, greater strength, and more endurance.

No complete record of the extent to which isometric training is being used is available, but indications that this technique is becoming more extensively used are certain. Athletes in football, track, baseball, basketball, and weight lifting are known to be using isometric training. (74)

Therapists are now using isometric training in clinical situations for physical therapy. The clinical advantages and disadvantages of isometric training have not been fully resolved but Rose, Radzminski, and Beatty (75) express the impression that brief maximal contractions give the patient the same desirable effect as more conventional progressive resistance exercises.

CHAPTER III

PHYSIOLOGICAL BASIS FOR PROGRESSIVE RESISTANCE EXERCISE

In order to more fully understand the components of physical fitness mentioned in chapter one, it seems meaningful to examine each of these attributes as they relate to physical performance. This chapter also includes the rationale for hypothesizing that progressive resistance effort will affect those attributes. A summary of related literature and hypotheses to be tested attempt to establish a meaningful framework into which the experimental programs can be cast.

Strength

Briefly defined, strength is the tension that a muscle exerts as it contracts. Muscular strength then, pertains to the severity of contraction against resistance. The severity of this contraction in a healthy muscle depends upon a number of factors: body temperature, number of muscle cells, size of muscle cells, and magnitude of the stimulus.

Morehouse and Miller (56, p. 60) state that muscular contraction is most powerful and rapid when the temperature of the muscle is slightly above normal body temperature. They further explain that this slightly higher temperature allows a faster contraction through lower viscosity of the tissues involved, more expedient chemical exchanges, and more efficient blood circulation.

Perhaps the most important factors determining the strength of a healthy muscle are number of cells and size of these cells. Since these two factors constitute most of the size of a muscle, the strength of a muscle is proportionate to its size providing that the size is not enhanced by fat. Any size contributed by fat not only lacks contractile power, but it also acts as a friction brake, limiting the rate and extent of shortening of the muscle fibers. (56, p. 59)

Since the number of cells in the muscle system is established by heredity, training emphasis must be placed on conditioning these natural attributes. As mentioned above, the size of the muscle is directly related (barring fat) to the ability of the muscle to contract with strength. The increase in size of skeletal muscles as a results of exercise is due to an increase in the cross section of the various muscle fibers and fascia of the muscle. (50, p. 53)

To condition these cells for strength, it seems necessary to refer to a basic ecological principle of adaptation and design training procedures utilizing that concept. That many muscle cells remain inert under normal living conditions of modern man appears to be quite understandable. These cells unless assigned contracting responsibilities will atrophy. The frequency of exertion for retention of maximal strength has not been fully determined, but DeLorme (22) indicates that one or two exercise periods weekly may be sufficient to maintain strength.

On the other hand, to develop maximum strength in a muscle the muscle must be put to stress to which it is not accustomed. This is the principle underlying progressive resistance exercise for strength development. Acceptance of this principle by physiologists and physical educators seems evident in the following quotations:

> The stimulus necessary for an increase of muscular strength is an increase in the tension over that previously exerted. This is the "overload principle" and it is the domination factor in strength development. No matter how much a muscle is used or fatigued it will not become stronger unless it is overloaded. (55, p. 16)

> It is a physiological fact that strength can be increased only by the muscle contracting against a reistance that calls forth effort. The degree of increase depends upon the degree of resistance, with maximal strength being produced by maximal effort. During training, as a muscle increases in size and strength, the load against which the muscle is working (developing tension) must become progressively greater and greater. (50, p. 53)

> It cannot be overemphasized that no augmentation in muscular power *per se* will occur when the amount of work done per unit of time falls easily within the functional capacity of the groups being treated. (36, p. 303)

> Whenever a healthy muscle is required to perform heavy work over any extended period of time, it increases in volume and, proportionally in strength and endurance. (32, p. 281)

> Muscles strengthen only when they work over and above their previous requirements -- the "overload principle", (72, p. 40)

> No matter how much a muscle is used, it will not grow larger or stronger until it is overloaded. (83, p. 150)

> What was clearly established by the work of Petow and Siebert is the fact that nothing but an increase in intensity of work above that previously demanded of a muscle is the stimulus for an increase of muscular strength. (61, p. 41)

To investigate the stimulus which determines the severity of muscular contraction, the reader should first understand the neural stimulation involved. Morehouse and Miller (56, p. 30) effectively summarize the significance of the stimuli as they relate to the development of maximal muscular contraction:

> The nerve impulse, which originates in a motor nerve cell in the spinal cord, travels along a motor nerve fiber to its termination in a muscle fiber. The nerve impulse is transmitted along the membrane of the nerve fiber by means of local electrical currents that flow between the resting and excited part of the membrance. It is a traveling wave of electrochemical change; as it travels along the nerve fiber it excites the next region of the fiber, while the region of the fiber just traversed reverts to the resting state. When the impulse reaches the junction between the nerve fiber and the muscle fiber, it causes the release of a chemical substance, acetylcholine, which transmits the excitation to the membrane of the muscle fiber and is then rapidly destroyed by the enzyme cholinesterase. The muscle membrane distributes the excitation over the whole length of the muscle fiber, but the manner in which the excitation is transmitted to the contractile myofibrils in the interior of the muscle fiber has long been a mystery.

With this in mind the extent of contraction can be determined by the number of motor units (muscle fibers controlled by a single nerve fiber) put into force simultaneously or the frequency of stimuli to the muscle, which may contain as many as 300 motor units. (56, p. 31) For maximal strength exertion of the muscle, the greatest possible number of nerve impulses per second would necessarily stimulate all motor units of the muscle.

Endurance

Endurance is the capacity of the muscle to maintain a sustained contraction or to repeat numerous contractions. This capacity depends on inherent muscular strength and the efficiency with which the cardiovascular system replenishes supplies of oxygen and nutrients to the contracting muscle and removes waste products from the muscle.

Obviously a well developed muscle is stronger than a less developed muscle. The strong muscle, when assigned a task of contraction, will not be taxed so severely as will the weak muscle. Since the demands of the task placed upon the strong muscle are less strenuous, fewer of its muscle fibers will be called into play. As these fewer muscle fibers are fatigued by contraction, others are substituted by neural impulses and take up the contraction while those initially contracted are allowed to relax. Thus, a system of "platooning" allows more repeated contractions or a longer duration of contraction.

The cardiovascular system, which conveys necessary nutrients and oxygen to the cells where they are used to produce energy, depends upon an efficient flow of blood to the activated area for endurance. The actual factor of endurance as it relates to blood flow is directly related to the number of capillaries in the muscle. (62, p. 37) In laboratory situations the number of capillaries in the heart and specific skeletal muscles has been increased 40 to 45 percent through training. (56, p. 259) Karpovich (38, p. 10) states that there are often over 4000 capillaries per square millimeter in a cross section of muscle tissue.

Speed

That progressive resistance exercise will facilitate speed of movement has long been seriously doubted -- especially by the lay public. In examining the factors affecting speed of movement in view of what is now contended by physiologists, the heretofore common belief that progressive resistance would retard speed seems to be quite fallible.

According to Massey (50, p. 58) the following components result in the ability to produce speed:

> The speed of muscular movement is determined by the hereditary characteristics of the nervous system, the physiological condition of the muscle, and motor learning.

Obviously a program of progressive resistance can not affect the hereditarily determined potential of a person, but it can, as shown above, produce desirable physiological effects on the condition of skeletal muscles, i.e., reduction of fat, provision of adequate foodstuffs through proper circulation, strength, capacity to overcome inertia, and endurance to maintain or repeat tension if effort is sustained.

Coordination

Massey (50, p. 59) defines coordination as "the capacity to bring into play the proper amount of muscular tension at the right time, and to apply it in the right direction to accomplish a specific motor task."

DeLorme and Watkins (22, p. 11) advance the idea that neuromuscular coordination and motor learning are improved through progressive resistance exercise by the intense concentration and high degree of cerebration involved in overcoming maximal resistance.

Klein and Hall (39, pp. 48-49) support this contention by writing:

> The indications are that maximal stimulus of the neurological systems, as well as the muscle fibers within each muscle group, can be adequately affected only with the maximal or near-maximal loading of the muscle capacity. If underloading is applied, neurological stimulation and muscle fiber action cannot be expected to take its maximal effect.

The two publications mentioned above (Klein and Hall, and DeLorme and Watkins) indicate that a more efficient muscle stimulation would result from the utilization of progressive resistance. Whether this improved stimulation of muscles is beneficial in neuromuscular efforts calling for less than maximal exertion has not been fully examined.

Some evidence that weight training will improve coordination is offered by Calvin (10) in his finding that an experimental group of weight trainers did better than a matched group of non-weight trainers who were engaged in conventional physical education activities.

Related Literature

That progressive resistance exercise has a significant effect on those who pursue it as a practice is generally agreed, but the causes and extent of this effect are not accepted by all who have studied this technique.

Several studies which substantiate weight training for strength development have been reported during the last fifteen years. Chui (14) wrote that a program of physical education failed to cause the increases in body weight and physical performance that the twenty-three weight trainers of his comparison achieved. Capen (11), and Masley et al., (49) also used college physical education students as controls against which a comparison of weight training could be made. Both studies strongly indicated the superiority of weight training for strength development. Berger (8), using 177 college males as subjects, experimented with nine different training procedures for strength development. He concluded that three sets of six repetitions induced the greatest gain in strength, although strength gains were recorded for all groups.

Kuzintz and Keeney (42), using an experimental sample of twenty-three weight trainers in junior high school, found that the weight trainers made significant gains in weight as well as significant increases in strength tests and all other performance tests.

Although the primary purpose of their experimentation was not to validate weight training for strength development, Chui (13) and McCraw (53), in comparing the effects of isometric exercises, speed exercises, and weight training concluded that weight training causes significant increases in strength of college males. Rose et al., (75), Baer et al., (3), and Liberson (47) found that progressive weight exercises will develop strength in adults. Rasch and Morehouse (70), in experimenting with a sample of osteopathy students, concluded that strength gains through weight training were significant and rapid.

Houtz, Parrish, and Hellebrandt (36), using women as subjects, discovered that not only did strength increase during the weight training program, but continued to increase after termination of the weight training. They confessed that they did not know specifically what caused these strength increases, but concluded that "morphological, biophysical, and physiological changes probably take place concurrently during training."

Muller (61), in citing the advantages of isometric training, concludes that a 40 per cent maximal exertion each day will develop muscular strength as fast as it can be developed. This corresponds closely with isometric experimentation done earlier by Hettinger and Muller which led them to report that a two-thirds maximal contraction of six seconds daily would result in maximum strength development. They attributed this development to the reaction of the muscle to the occlusion of blood flow during contraction. Morehouse, Rasch, and O'Connell (56) designed experiments to verify this thesis but were unable to get significant results with application of heat or external occlusions. Asa (2) further refuted Hettinger and Muller's contention of a single daily contraction being the fastest method of strength gain by reporting that twenty contractions produced better results than did a single contraction. Liberson and Asa (46) reiterated this point and further contended that while a sustained contraction of the muscle might obstruct blood flow, repeated contractions might be conducive to expedient blood flow. They further contended that the most efficient position for exercising the muscle was the normal resting position of the muscle, a process that can be done more easily isometrically.

Wickstrom (93) attempted to verify the results of Hettinger and Muller by experimenting with a daily two-second maximal contraction. He found that an overall loss of strength resulted from six weeks of such training by a sample of graduate students.

It was concluded by Walter, Stewart, and LeClaire (91) that full isometric contraction was superior to two-thirds maximum contraction.

Salter (76) found no significant difference in strength improvement resulting from the comparison of a two minute and fifteen minute isometric workout.

In attempting to determine the better isometric routine for develing strength in postpubescent males, Rarick and Larsen (68) compared a program of six second, two-third maximal contractions against a program of twelve second contractions. Both groups made significant gains, but there was no statistical difference between groups at the end of the training period. Wolbers and Sills (95) found that the six second contraction resulted in significant strength gains for high school boys, but they tried no other routine for comparative performance. Liberson and Asa (46) concluded that twenty contractions resulted in greater gains of strength and endurance than did a single contraction.

Bender (5) writes that isometric training is good for therapeutic purposes where strength is needed for stabilizing joints in a certain position, but cautions against "gross" isometric contraction will develop strength of a muscle only for the position in which it is exercised. He further contends that isometric exercise has the inherent danger of overdeveloping large muscles while the smaller synergetic muscles atrophy.

Darcus and Salter (21, p. 336) report findings that are not clearly in agreement with Bender. They state:

> Although static training was carried out in only one position of the hand while dynamic training involved movement from this position through a variable portion of the total range, an increase was found in all positions under both conditions.

They also cast doubt on Bender's theory of unworked synergetic muscles, for they report improvements of muscular potential of the antagonists of the same side and corresponding groups of muscles on opposite side.

Additional doubt of the validity of Bender's contention that the weaker muscles weaken further through isometric effort is caused by Slater-Hammel's (80, p. 24) reporting:

> Fron the records obtained, it was concluded that the exercise of particular muscles in an arm resulted in a diffusion of motor impulses which produced contractions in related muscles of the same arm. This, presumable, accounted for the improvement of muscular performance in the accessory muscles of the exericsed arm.

Massey (50, p. 52) states:

> Limitation of muscular contraction to selected muscles is quite impossible when the resistance is heavy. The automatic static contraction of muscle groups in adjacent joints or even in muscle groups far removed from the moving levers in no way detracts from the exercise, but actually make it more valuable in terms of physical fitness.

Further studies of neuromuscular activity by Gardner (27), Hellebrandt (29), Slater-Hammel (79), and Hellebrandt et al., (33) indicate the complexity of this phenomenon and conclude that exercise against resistance is never confine to the anatomical prime mover.

Attempts to determine the superiority of progressive weight training or progressive isometric contraction for strength gain resulted in no significant differences being reported by Salter (76), Wallace (89), Baer et al., (3), Mathews and Kruse (51), Chui (13), and Darcus and Salter (21).

Berger (7) found that the subjects who trained with isometrics did better than the weight trainers on isometric strength test and that the weight trainers did better than the isometric group on strength tests involving movement.

In reporting the results of a strength comparison, Rasch and Morehouse (70) concluded that the weight trainers improved more on strength tests than did the isometric group even though both groups increased significantly.

Opposing findings were reported by Walter, Stewart, and LeClaire (91). They cite both programs as being responsible for statistical gains in strength, but with greater gain resulting from isometric activity. Liberson (47) concludes that both the single isometric contraction and the multiple isometric contractions resulted in greater strength gain than did the progressive weight group.

There seems to be some doubt expressed by Ferguson (26) and Cureton (18) that the same training techniques will promote strength gains and endurance capacity. In fact DeLorme (23) originally prescribed a mixed routine of low repetition high resistance exercises for strength and high repetition low resistance exercises for development of endurance. Liberson (47), however, reported isometric contractions promoted a high degree of endurance while developing strength.

Endurance is the result of the nature of the demands placed upon the musculature, according to Start and Graham (81) who indicated that many previous findings might be inconclusive when related to submaximal effort. They report that when muscular contraction was not severe enough to produce occlusion of blood flow, circulatory efficiency as well as strength had an effect on endurance.

Research findings by Capen (12) showed no significant differences in a biweekly weight program and a conventional physical education program involving activities which are generally considered to be conducive to developing endurance. Kusintz and Keeney (42) also found endurance gains through a weight program.

Nagle and Irwin (63) failed to detect a significant difference between a weight training program involving high resistance and low repetition when compared with a low resistance high repetition program.

Attempts to determine the better of the two programs (weight and isometric) for the development of endurance have proven quite inconclusive. Howell, Kimoto, and Morford (37), report that eight week programs of isometric and weight training produced significant gains in endurance as measured by a bicycle ergometer, but that there was no significant difference between the gains of the groups. An earlier experiment by Dennison, Howell, and Morford (24) produced the same comparative results. This earlier program used pullups and dips as a test of endurance.

Wallace (89), however, concluded that isotonic exercises produced endurance gains significant at .01 level wheras the isometric gains were significant at the .05 level.

Opposing results were reported by Liberson and Asa (46) when they cite gains of 103 per cent and 203 per cent for isotonic and isometric programs respectively.

Additional conflicting evidence was written by Walters et al., (91) when they revealed that full isometric tension developed endurance significant at the .01 level of confidence and two-thirds maximal tension resulted in such gains at the .05 level. The weight program of their experiment resulted in no significant gains in endurance.

Baer et al., (3) report no statistical difference among experimental groups of low resistance isotonic, high resistance isometric, and high resistance isotonic programs in their development of endurance.

In a recent study by McCraw (53), endurance was reportedly developed better by those activities which resulted in a great number of repetitions per effort, with those activities requiring rapid contraction against resistance adding to endurance gain.

One of the most common criticisms leveled at progressive resistance programs and weight training in particular is that it will result in the practitioner's becoming "muscle-bound". The condition implies having some of the muscles tense, enlarged, and of impaired elasticity - a condition sometimes attributed to excessive athletic exercise. Although the concept appears to be quite acceptable to many laymen, the opinions and research findings of physiologists and physical educators seem to indicate that no such physical impediment exists.

If such a hindrance to physical activity existed, it would seem (in light of the above definition) to impede coordination, agility, flexibility, and speed of muscular movement.

Leighton (43, p. 583) in summing up a comparison of flexibility between randomly selected sixteen-year-old boys and highly conditioned weight trainers states:

> The evidence indicates that even the champion weight lifters and body builders who possess the ultimate in body strength and muscular bulk are more flexible than the average boy of sixteen years in a mojority of the movements of the body.

In a study using boys of comparable age groups, Calvin (10, p. 397) compared a group pursuing a conventional physical education program with a group practicing weight training. He concludes:

> The results of this study gave no indication that muscular development associated with weight training over a four-month period of time had in any way a deleterious effect on the motor coordination of a group of high school boys, ranging in age from 14-18 years. In fact, the results seemed to indicate that progressive resistive exercises in the form of weight training tend to affect favorably the motor coordination of high school boys.

In reviewing the physiological rationale behind progressive resistance exericse, Rasch and Freeman (72, p. 40) refute the "muscle-bound" myth by writing:

> Increase in muscle power does not cause slowness of movement, and controlled weight training studies have shown increases in agility, coordination, and general athletic ability.

It is highly possible that this common misconception might have originated because the strongmen of the previous century tended to be pounderous, and no demands were made for them to display speed, agility, flexibility, or coordination. Karpovich (38, p. 101), however, concludes: "Well trained men may have large muscles, but, if they are lean, their flexibility remains normal."

A more pointed rebuttal is offered by Massey (50, p. 8) when he contends that "muscle-boundness is a figment of the imagination and no such condition actually exists . . ." He then indicates that weight trainers are more flexible than most athletes.

Wilkin (94) compared varsity weight lifters and beginning weight lifters with a control group of swimmers and golfers. He found no significant difference in the muscular speed of those three groups with regard to arm movement.

A similar comparison by Zorbas and Karpovich (96), which used non-lifters from the Liberal Arts College at Springfield as a control group, showed weight lifters possessed greater forearm speed. This superiority proved significant at the .01 level of significance.

Masley, Hairabedian, and Donaldson (48) showed greater gains for weight trainers in both speed and coordination than for a comparable number of volleyball players. These gains were also somewhat superior to a control group of listeners to sports lectures.

Chui (13) found that gains in strength correlated highly with gains in speed of movement. He found no significant difference in speed gains of isometric trainers and weight trainers.

Kusintz and Keeney (42), Massey and Chaudet (49), and Counsilman (17) offered further evidence to indicate that weight training has no deleterious effect on the agility of those who practice this technique.

Although no study is available to determine the effects of isometric training on coordination and agility, there seems to be no physiological rationale to indicate any debilitation of these physical attributes.

The lack of consensus on the reported research might be expected from the wide range of training techniques and procedures involved.

Durations of programs varied from eight days (91) to thirty-six weeks (3); training effort varied from a single two-second contraction (93) to exhaustion (91); and experimental samples ranged from junior high school boys (42) to men of forty-five years of age (3). Some experiments used females for samples (89) (76) and another used both sexes in the sample (93).

In view of the conflicing research findings, a consensus of the value of isometric activity for developing the various attributes of physical fitness appears quite impossible. Weight training, however, seems to enjoy consistantly favorable reports of its ability to develop these factors which produce positive results in terms of physical performance. Therefore, formal examination of the efficacy of isometric training was posited by testing the following hypotheses:

Hypotheses to be Tested

1. The students who experience the isometric program will improve on performance of the Youth Fitness Test more than the students who experience the weight program ($p \leq .05$). This hypothesis was derived by assuming that weight training developes strength, endurance, coordination, and speed through maximal exertion. If so, comparable maximal exertion in isometric training should produce equal or better results. Maximum exertion can be more easily attained in isometric training; therefore, the results might be more significant. It was also assumed that these attributes which can be developed by training were those necessary for desirable performance on fitness tests.

2. The students who experience the isometric program will increase more in body weight than will the students who experience the weight

program ($p \leq .05$). As the skeletal muscular system developes, it also becomes larger, which causes an increase in weight. Also, as fatty tissue is replaced by sounder tissue (assuming a fiarly constant caloric intake), body weight should increase.

3. The students who experience the isometric program will continue the training beyond school more than the students who experience the weight training ($p \leq .05$). One objective of the physical education program is to provide skills and interests that can be used into non-school life. Since isometric training requires little space and no equipment, it would follow that the participants will be more inclined to incorporate such a program into their activities beyond school.

CHAPTER IV

EXPERIMENTAL SAMPLES, PROGRAMS, AND PROCEDURES

This chapter describes the sample of the population upon which this experiment was cast, defines and explains the instruments which were used to indicate change as a result of the experimental programs, and presents a description of the programs involved. It further enumerates the steps taken in setting up the programs, gathering the data, and handling the data to extract meaningful results.

Student Sample Involved in the Study

The student sample for the experiment consisted of 192 freshman males in the Alice Robertson Junior High School and the West Junior High School, both of which are located in Muskogee, Oklahoma. These subjects represented the schools and training programs in the following manner:

TABLE I

DISTRIBUTION OF SUBJECTS AT THE BEGINNING OF THE PROGRAM

School	Alice Robertson	West	
Weight Program	63	28	91
Isometric Program	64	37	101
Total	127	65	192

The subjects were randomly assigned to the programs in the Alice Robertson Junior High School, but such assignment was impossible to arrange in the West Junior High School because the physical education instructors in that school did not have concurrent classes and assignments to physical education classes were largely determined by class capacity in physical education and other subjects. Therefore, the numbers involved in the experimental treatments at the West Junior High could not be equated.

During the second or third week after pretesting, the instructor who was supervising the isometric aspect of the program in the West Junior High expressed dissatisfaction to his principal, who in turn suggested that he terminate that phase of the program. Such decision was interpreted by this author as a result of mixed classes (i.e., seventh and eight grade students mixed with the freshmen) which could not be adequately supervised (in the instructor's opinion) without additional personnel, and this decision should not be construed as a criticism of this technique of training.

Further losses of subjects were sustained by sixteen subjects (ten weight and six isometric) transferring from the school district, seventeen (nine weight and eight isometric) changes of schedule, three (two weight and one isometric) dropouts, six subjects (four weight and two isometric) having ten or more absences, and six (four weight and two isometric) withdrawing from physical education for medical reasons.

TABLE II

DISTRIBUTION OF SUBJECTS AT THE
END OF THE PROGRAM

School	Alice Robertson	West	
Weight Program	51	11	62
Isometric Program	45	--	45
	96	11	107

These students in the isometric program ranged in age from 165 months to 199 months with a median age of 171 months at the beginning of the program. The students in the weight program ranged in age from 155 months to 196 months with the median age of 174 months at the beginning of the program.

The subjects of the isometric program ranged in weight from 78 lbs. to 250 lbs. with the median weight of 116 lbs. at the beginning of the program. At the same time the weight training subjects median weight was 117 lbs. with a range of 82 lbs. to 255 lbs.

Height variations ranged from 59 inches to 72 inches with a median of 66 inches at the beginning for the weight trainers and ranged from 59 inches to 72 inches with a median of 65 inches for the isometric trainers.

See pages 84 to 85 of Appendix C for graphic illustrations of the above figures.

Instruments Used in the Study

The principal instrument used to measure the various attributes of physical fitness was *The Youth Fitness Test*, a battery of seven subtests which was devised under the auspicies of the American Association for Health, Physical Education and Recreation (AAPHER). The optional aquactic subtest was not considered, for no norms are reported in the *Youth Fitness Test Manual*, and no pool facilities were available for testing the subjects of the experimental programs.

The development of the *Youth Fitness Test* came as a direct result of President Eisenhower's directive which formed the Council on Youth Fitness in September, 1956. Following preliminary meetings by the AAHPER, the Research Council of the AAHPER met in Chicago in February of 1957 and agreed on these various subtests. During the schol year of 1957-58 the *Youth Fitness Test* was standardized on 8500 boys and girls throughout the country the grades five through twelve. The first edition of the test manual was copywrited and distributed in that year and revised in 1961. Troester (86, p. 101) reports that the *Youth Fitness Test* has been administered to approximately twenty-five million students between grades five and twelve.

The seven subtests which are administered to boys are pullups, situps, standing broad jump, shuttle run, fifty-yard dash, softball throw, and 600 yard run-walk. For a detailed description of the seven subtests, consult pages 79 to 83 of the Appendix B.

The relationship of height to weight is used in this study to indicate the change of body weight that can be attributed to muscular development. This indication can not be accepted as precise or conclusive, for there is no expedient means of ascertaining how much fat, if any, is lost or gained by the participants. Furthermore, there is no reason to believe that either program will cause the participants to gain or to lose fat without some concurrent adjustment of caloric intake. (38)

Although a positive correlation between weight gain and strength gain exists, there seems to be some doubt of the optimum relationship. Murray and Karpovich (62, p. 44) recommend:

> Additional investigation into this height-weight relationship is very desirable in order to determine at what point an increase in body weight becomes a handicap rather than and asset.

Although some indication might be seen in these data, the primary concern of this comparison remains to indicate which program will more greatly affect the height-weight ratio of the subjects involved.

Description of the Program

In light of the lack of agreement as to which particular progressive resistance routines within each technique produced the most efficient grains in the various attributes of physical fitness, an attempt was made by the author and the physical education instructors in Muskogee to develop programs which would compare closely in expenditures of time and effort.

The activities were conducted three times weekly. Time involvement for each session was determined by the extent of time necessary to complete two sets of six to eight repetitions of ten basic exercises for the weight groups and two sets of eight second maximal contractions on ten basic exercises for the isometric groups.

In spite of good organization and a large number of exercise stations in the weight programs, the time involved in this type training ran one hundred per cent greater than the time involved in the isometric program.

The ten basic exercises mentioned above for the weight programs include two-arm curl, supine press, posterior military press, leg press, toe rise, situps, supine horizontal arm lift, straight arm pullover, prone horizontal arm lift, and shoulder shrug. Pages 86 to 87 of Appendix D include a description, drawings, and muscle groups involved in each of these exercises.

Although no literature which names the isometric exercises is available, the descriptive names applied above to the weight exercise could well be applicable to their isometric counterparts. The isometric programs outlined and prescribed in Isometric Exercises by Wallis and Logan and the section on static exercise in Weight Training in Sports and Physical Education were adapted to correspond with the weight program mentioned above. A description of these ten exercises, along with illustrations and muscle groups involved is found in pages 69 to 78 of Appendix A.

Procedures Used in the Collection of Data

The writer, upon approval of his research proposal by the graduate advisory committee, conferred with Mr. Henry A. Vaughan, Director of Safety, Health, and Physical Education, a division of the State Department of Education. During this visitation, Mr. Vaughan mentioned some schools in the state which he thought might have the necessary facilities, subjects, staff, and interest to conduct such an experiment. One of these schools was Muskogee, Oklahoma.

Upon contacting the Director of Physical Ecucation in Muskogee, Mr. Alph Stanphill, the writer was advised to contact Mr. David Shelton, head instructor of physical education in the Alice Robertson Junior High School.

By visiting with Mr. Whitt K. Abbott, principal of the Alice Robertson Junior High School, Mr. Shelton and one of his colleagues, Mr. Hulen Staten, the author found interest and enthusiasm for such activities and gained their committment of cooperation for the experimental programs.

However, late in the 1963-64 school year an administrative directive removed all inter-scholastic athletes from the regular physical education classes, thereby limiting the number of subjects available in the Alice Robertson Junior High School for the desired sample.

On subsequent visitations to Muskogee during August of 1964, the writer, with the cooperation of Mr. Stanphill and Mr. Shelton, enlisted the cooperation of Mr. Richard Adkins and Mr. Verl Keeter, physical education instructors, and Mr. Eiland Rainwater, principal of the West Junior High School of Muskogee, to extend the comparative programs into that school also.

Before the experimental programs began, assessments of age, height, weight, parent's occupation, and physical fitness scores were attained for each subject in the program. Such data was attained during the week of September 7, 1964.

At the close of the semester the same information (except age and parent's occupation) was gathered for each participant to compare with the pre-program data.

During the first week of March, 1965, a schedule was administered to each of the subjects who had completed the programs to determine which of the programs had lead to a greater degree of participation after the termination of the required program. An additional purpose of the follow-ups was to attempt to get an indication of the subjects' attitudes the programs.

Treatment of the Data

Since the primary concern of the comparative study was to determine the differences of physical fitness components as they are affected by the two progressive resistance programs in question, an analysis of covariance statistical analysis was used. This technique is capable of detecting statistical differences between the posttest scores while compensating for pretest differences, if any existed. A separate analysis was made to compare the two programs on each of the seven subtests of the Youth Fitness Test and the height-weight relationship.

There is also a strong possibility that one program might be more conducive to development of physical fitness for those subjects with low initial scores than for subjects with high initial scores or vice versa. The extreme quartiles of both groups, as they scored on the pretest of each of the subtests, composed subgroups whose posttest scores were compared by an analysis of variance to determine if a differential training effect existed for those with differing pretest scores. (The situp test was excluded from this analysis. Since a substantial number achieved the maximum score on this test, quartile comparisons were not feasible.)

A coefficient of correlation was derived from a comparison of all eight components of physical fitness as measured by the posttest. Such a study of relationship was an attempt to validate the height-weight relationship as a unit of measurement for physical fitness and to explore the possibility of determining a composite score for the _Youth Fitness Test_.

For a comparison of the extent of continued participation and for a comparison of the subject's appreciation of the programs, the Kolmogorov-Smirnov two-sample comparison of groups was used. The chi-square test was used for all other comparisons on the follow-up.

CHAPTER V

RESULTS OF THE STUDY

This chapter relates the pertinent findings of the statistical tests which were used to gauge the efficacy of the data which were compiled. These findings are reviewed in light of the originally cited hypotheses.

Group Comparisons on the *Youth Fitness Test*

The most significant effort of this study was to determine the differential effects of the two progressive resistance programs as they related to the physical fitness of the subjects involved. Since the *Youth Fitness Test* was used to measure such fitness, the following hypothesis was previously cited:

> Hypothesis 1. The students who experience the isometric program will improve on performance of the *Youth Fitness Test* more than the students who experience the weight program ($p \leq .05$).

The F ratios which were extracted from the analysis of covariance (See Table III) indicate that the above hypothesis must be rejected for all but one (broad jump test) of the subtests of the *Youth Fitness Test*. The hypothesis must be confirmed on this subtest because the isometric group succeeded in making greater gain than their counterparts of the weight group. This difference was significant at the .01 level point of confidence.

Further study of Table III will reveal that all but one of the t ratios, which were used to measure pretest-posttest change within groups,

TABLE III

GROUP COMPARISONS ON YOUTH FITNESS TEST

TEST GROUP	Number	Pretest Mean	Pretest S.D.	Posttest Mean	Posttest S.D.	t Ratio Pretest-Posttest	F Ratio Between Groups
Height-Weight							
Weight	62	1.826	.58	1.929	.39	8.17*	.857
Isometric	45	1.862	.43	1.952	.47	6.38	
Situps							
Weight	62	91.61	17.55	95.77	12.71	2.06**	.912
Isometric	45	90.89	21.01	93.22	17.78	1.13	
Pullups							
Weight	62	4.98	4.39	6.02	4.12	4.38*	2.01
Isometric	45	4.73	4.09	6.20	3.39	6.69*	
Broad Jump							
Weight	62	75.05	10.26	77.63	10.02	4.65*	10.5*
Isometric	45	71.89	10.69	77.55	11.35	8.17*	
50 Yard Dash							
Weight	62	7.84	.66	7.30	.75	5.96*	.078
Isometric	45	7.94	.78	7.40	.73	9.48*	
Shuttle Run							
Weight	62	10.9	.8	10.6	.8	2.55*	2.86
Isometric	45	10.4	.9	10.1	.7	3.43*	
Softball Throw							
Weight	62	135.24	34.20	141.59	34.99	3.11*	.930
Isometric	45	135.40	20.82	139.00	23.98	2.54	
600 Yard Run							
Weight	62	2.19	.43	2.02	.38	7.26*	.827
Isometric	45	2.15	.46	2.03	.59	2.77*	

*.01 point of significance **.025 point of significance

are significant. This single t ratio, which is not significant, is found on the comparison (pretest-posttest) of scores for the situp test of the isometric group. Significant gain on the situp test by the weight group was reached at the .025 point of confidence.

It should be mentioned that the situp test has a ceiling of one hundred repetitions. (See page 80 of Appendix B). Such a ceiling negates the propriety of using a parametric statistical analysis, so the author employed the Kolmogorov-Smirnov two-sample (78) test to see if differences existed between the pretest and posttest for each of the two groups. With this technique, the chi-square approximations were found to be 5.40 for the isometric group and 1.55 for the weight group, neither of which was significant at the .05 point of confidence.

Group Comparison on Height-Weight Relationship

Theorizing that the development of the skeletal musculature would induce weight gains which would exceed normal growth rates of height and weight, the author tested the following hypothesis:

> Hypothesis 2. The students who experience the isometric program will increase more in body weight than will the students who experience the weight program ($p \leq .05$).

The small F ratio shown for this comparison on Table III indicates that this hypothesis must be rejected. Although highly significant gains in weight as it relates to height were achieved by both groups, the difference between groups proved negligible.

Group Comparisons on Continuation of Program

In an attempt to determine which of the programs would lead to a higher incidence of continued participation after the experimental programs were terminated by the schools, the following hypothesis was tested:

> Hypothesis 3. The students who experience the isometric program will continue the training beyond school more than the students who experience the weight training ($p \leq .05$).

Again using the Kolmogorov-Smirnov two-sample test to measure differences of distributions, the value of chi-square was found to be .405 when computed from the following table:

TABLE IV

FREQUENCY OF PARTICIPATION SINCE TERMINATION OF THE SCHOOL PROGRAM

	None	Not Regularly	Once Each Week	Twice Each Week	Three Times Each Week
Isometric	19	18	8	8	5
Weight	14	15	3	8	5

This chi-square value (.405) is not significant at the .05 level. Perhaps of greater importance than finding no difference in continued participation was the discovery that neither continued the program to any appreciable extent. Computing chi-square with expected frequencies evenly distributed for each of the cells in Table IV, it was found that both groups failed to continue with the program which they had learned. These chi-square values were 14.22 (.01 level of confidence) for the weight group and 11.67 (.02 level of confidence) for the isometric group.

Quartile Comparisons

As suggested by McCraw (53), some effort was made to determine the net effects of training programs for those subjects with differing initial statuses. To explore such different training effects, the pretest highest quartiles and pretest lowest quartiles of each group were compared by analysing the posttest scores with an analysis of covariance. Table V shows the results of such comparisons.

TABLE V

EXTREME QUARTILE COMPARISONS
ON YOUTH FITNESS TEST

Test	Number	Degrees of Freedom Greater Mean Square	Smaller Mean Square	F
Height-Weight Relationship	48	3	43	.438
Broad Jump	56	3	51	3.45**
50 Yard Dash	59	3	54	.216
Shuttle Run	56	3	51	1.80
Softball Throw	56	3	51	1.05
Endurance	49	3	43	1.45
Pullup	50	3	45	.574

**.05 point of significance

Obviously there is no training effect that is more applicable to any one of the extreme quartiles with the exception of the board jump test. In determining the source of the significant F ratio on this subtest, it was found that the highest quartiles of both experimental groups made significantly (.05 level of confidence) greater gains during the program than their lowest quartile counterparts.

Correlations of the Dependent Variables

To explore the possibility of assigning a composite score for the seven subtests of the Youth Fitness Test coefficients of correlation were extracted between each of the seven subtests and the height-weight relationship.

Tables 6-9 on pages 51 and 52 show these coefficients of correlation. In reading the tables, subtests which are timed (i.e., 50 yard dash, shuttle run, and 600 yard run), will appear as negatively correlated with untimed subtests when a positive correlation exists and vice versa.

It would appear that the height-weight ratio as an index for physical fitness is not a viable dimension. Rather, as the height-weight ratio made significant increases, as it did from pretest to posttest, the negative correlation with physical performance became more pronounced. This happened in all instances except the softball throw test for both groups and the pullup test for the isometric group.

Other Data From the Follow-up

In addition to finding the incidence of continued participation of the progressive resistance routines, other data were gathered in an attempt to gain some insight into the subjects' attitudes toward the programs. (Appendix E contains the schedule which was administered to each student.) Students were asked to check the benefits which they

TABLE VI

CORRELATIONS OF DEPENDENT VARIABLES
FOR ISOMETRIC GROUP

PRETEST	Situps	Pullups	Broad Jump	50 Yard Dash	Shuttle Run	Softball Throw	600 Yard Run
Height-Weight	-.290	-.421	-.272	.180	.356	.151	.488
Situps		.369	.548	-.576	-.627	.375	-.705
Pullups			.610	-.648	-.617	.209	-.554
Broad Jump				-.872	-.824	.475	-.772
50 Yard Dash					.762	-.523	.799
Shuttle Run						-.375	.769
Softball Throw							.457

.01 level of significance = .267 .05 level of significance = .205
Correlations between timed and untimed tests are inverted.

TABLE VII

POSTTEST	Situps	Pullups	Broad Jump	50 Yard Dash	Shuttle Run	Softball Throw	600 Yard Run
Height-Weight	-.468	-.396	-.337	.327	.368	.057	.687
Situps		.513	.646	-.734	-.744	.303	-.682
Pullups			.568	-.626	-.559	.255	-.498
Broad Jump				-.884	-.673	.597	-.765
50 Yard Dash					.743	-.600	.762
Shuttle Run						-.524	.709
Softball Throw							-.469

.01 level of significance = .267 .05 level of significance = .205
Correlation between timed and untimed tests are inverted.

TABLE VIII

CORRELATIONS OF DEPENDENT VARIABLES
FOR WEIGHT GROUP

PRETEST	Situps	Pullups	Broad Jump	50 Yard Dash	Shuttle Run	Softball Throw	600 Yard Run
Height-Weight	-.085	-.381	-.225	.264	.546	.070	.543
Situps		.195	.247	-1376	-.357	.332	-.332
Pullups			.494	-.496	-.461	.328	-.518
Broad Jump				-.648	-.490	.598	-.649
50 Yard Dash					.363	-.486	.667
Shuttle Run						-.364	.607
Softball Throw							-.478

.01 level of significance = .228. .05 level of significance = .174
Correlations between timed and untimed tests are inverted.

TABLE IX

POSTTEST	Situps	Pullups	Broad Jump	50 Yard Dash	Shuttle Run	Softball Throw	600 Yard Run
Height-Weight	-.305	-.403	-.274	.377	.526	.069	.614
Situps		.142	.523	-.421	-.375	.310	-.453
Pullups			.479	-.555	-.467	.239	-.559
Broad Jump				-.768	-.535	.553	-.619
50 Yard Dash					.474	-.500	.712
Shuttle Run						-.313	.574
Softball Throw							-.379

.01 level of significance = .228 .05 level of significance = .174
Correlations between timed and untimed tests are inverted.

felt that they had derived from the program. Table X offers a compilation of the items which were checked.

TABLE X

EXPRESSED TRAINING BENEFITS OF SUBJECTS

EXPRESSED BENEFITS	Weight Group Who Checked This Item	Weight Group Who Didn't Check This Item	Isometric Group Who Checked This Item	Isometric Group Who Didn't Check This Item	Chi-Square
Physically More Active	25	23	25	20	1.57
Greater Appreciation For Physical Education	21	37	20	25	.71
Have Greater Stamina	21	37	19	26	.37
Feel Better	34	24	31	14	5.90**
Feel Stronger	47	11	24	21	9.07*
Have Better Posture	26	32	15	30	1.40
Have Less Sickness	15	43	18	27	2.32
Better Physique	19	39	18	27	.57
Other Benefits	12	46	10	35	.035

*.01 level of confidence **.05 level of confidence

A chi-square was used to determine statistical significance of the responses. The reason for one statistically significant difference (feel stronger) might be that the weight group expressed feeling stronger to a significant degree because they were aware of the increases in weights used for the various exercises in their program.

It might well be that the significant difference resulting from the isometric group's checking "feel better" resulted from their experiencing a sensation of muscular firmness which several isometric participants have related to the writer.

It should be noted that only one subject of each group checked no benefits, and only one isometric subject and two weight subjects checked all benefits.

When asked, "Of what value was the training program to you?" the subjects checked the following options:

TABLE XI

SUBJECTS' SUMMARY EVALUATION OF PROGRAMS

	Much Value	Some Value	Little Value	No Value
Weight	29	28	0	1
Isometric	21	21	1	1

In computing the significance of the value of each program with chi-square, the expressed values of the programs were significant at the .01 level of confidence. These chi-square values were 36.36 for the isometric group and 54.14 for the weight group.

The Kolmogorov-Smirnov two-sample test was applied to see if there was a significant difference between the summary evaluations of the subjects. The chi-square value of this test measured .078, which is clearly not significant.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In Summary

It seems only logical that the concern of individuals for a suitable level of physical fitness should develop into a social concern. This concern has been enhanced by the publicity given to this subject in recent years. Specific topics which have caused disturbed public attitudes are: (1) the discovery that European children are better developed in physical performance than American children, (2) increasing incidence of heart ailments and obesity as factors partially attributable to lack of proper physical activity, and (3) continued expansion of sedentary vocational pursuits.

A concerted effort to alleviate this problem was begun in 1956 with the formation of the President's Council on Youth Fitness which designed the Youth Fitness Test and used the test to evaluate the status of physical fitness of students in the schools of the United States. As a logical consequence to such evaluation, the Council published and disseminated a compilation of recommendations which are designed to promote a higher standard of physical fitness. Another primary objective of this organization is to increase the awareness of the problem of physical fitness deficiencies. The frequent advertisements via the news media are examples of their publicity campaign.

Although the recommendations of the President's Council on Youth Fitness represent the thinking of outstanding physical educators, their implementation has not been universal-particularly in small and/or under-financed schools.

In an attempt to devise a means of elevating the levels of physical fitness for those students who do not enjoy the facilities, staff, or time necessary to implement the recommendations of the President's Council, an experimental study was designed to test the efficacy of isometric training for the development of physical fitness.

Isometric training, a fairly recent innovation in athletic and therapeutic technique, is a progressive resistance routine which closely parallels the approach used in weight training. The principle of both routines is to overload the normal capacity of the muscles involved in the exercise effort.

Numerous research reports cite weight training as an expedient means of developing operational physical fitness in terms of strength, speed, coordination, and endurance - the principal components of physical fitness. Therefore, weight training offers a desirable standard against which isometric training can be compared. Such a comparison seems necessary to validate this technique in view of the conflicting research findings on isometric effort. These reports establish only one consensus in which much confidence can be placed (i.e., maximal isometric contraction developes muscular strength).

To facilitate the comparison of the two progressive resistance programs, all male ninth-grade students taking a required course of physical education in the Alice Robertson and West Junior High Schools of Muskogee, Oklahoma, were divided as evenly as possible into two experimental groups. Although these groups contained no students who participated in interscholastic athletics, the experimental isometric group contained 45 subjects and the experimental weight group contained 62 subjects.

The isometric group followed a routine of ten basic exercises. Two repetitions of each were executed with each repetition lasting for an eight second duration. The weight group followed a routine of six to eight repetitions of ten basic exercises. Each exercise was done twice per workout day. For both groups three workout days were scheduled each week for the duration of one semester, with the exception of the first and last weeks of the semester. These weeks were allocated for administering the <u>Youth Fitness Test</u> and for measuring the height and weight of the subjects. The relationship of these factors was to be used as an index of muscular growth.

The results of the pretest and posttest of the <u>Youth Fitness Test</u> and the ratio of height and weight were compared by an analysis of covariance to test the following hypotheses:

> Hypothesis 1. The students who experience the isometric program will improve on performance of the <u>Youth Fitness Test</u> more than the students who experience the weight program ($p \leq .05$).

> Hypothesis 2. The students who experience the isometric program will increase more in body weight than will the students who experience the weight program ($p \leq .05$).

Only one of the $\underline{F}$ ratios indicated statistical significance. In determining the cause of this significance, it was found that the isometric group made greater gain on the broad jump test than the weight group. This might indicate that a more efficient contraction can be attained through isometric effort or that the leg press machine which the weight group used to stabilize the resistance was noisy and unpopular.

Differences between means of pretests and posttest scores within groups were computed for t ratios. All reached significance except the situp test for the isometric group.

About six weeks after the termination of the experimental programs, a follow-up was made to gauge the degree with which the participants had continued the techniques they had learned.

The Kolmogorov-Smirnov two-sample test was used to test the following hypothesis:

> Hypothesis 3. The students who experience the isometric program will continue the training beyond school more than the students who experience the weight training ($p \leq .05$).

Although there was no significant difference between groups, it must be noted that computations of chi-square indicated that both groups significantly failed to continue their training programs beyond the requirements of the school.

In comparing the training effect of extreme quartiles within and between groups, it was found that the highest quartile of both groups (based on pretest scores) made significantly greater gain on the board jump test than did the lowest quartiles.

It is probable that the increase in height-weight ratio was largely attributable to heavier subjects who scored in the lowest quartile on the broad jump pretest.

It was also found that a high positive correlation existed between most subtests on the Youth Fitness Test. A negative correlation was found between height-weight relationship and all subtests except the softball throw.

Although there was no statistical difference between groups on their overall evaluation of the program, a significant number of both programs expressed that they valued the activity which they had experienced.

Recommendations

That physical fitness can be developed by these progressive resistance programs seems obvious. For schools which have adequate resources, some experience with both programs seems desirable in view of the desirability of teaching as many training techniques as possible. Furthermore, by combining portions of these programs, a more varied and interesting curriculum can be devised.

For schools which lack appropriate time, facilities, and staff, it seems that isometric activity is a valid technique for raising fitness levels of the students of those schools.

In view of the incongruity between the number of subjects who expressed feeling that the program was valuable and the small number who continued the technique beyond school requirements, it appears that a substantial number of the students grew tired of the routine. If this is a correct analysis of the inconsistancy, further studies might well be considered to determine the minimum frequency of activity necessary to maintain the desired level of physical fitness. Intermittent periods of these routines if proven effective, might also alleviate any monotony of training.

The high correlations generally found on the seven subtests indicates that fewer of these subtests are necessary for an indication of physical fitness. It might be feasible to administer a test involving running (e.g., 600 yard run) and a test requiring strength (e.g., pullup test) to indicate the performance fitness to students. Correspondence from Dr. Paul A. Hunsicker, Director of the AAHPER Youth Fitness Project, to the writer indicates that the normative structure of the Youth Fitness Test is being revised. He stated that this revision will be available later this year.

In view of the number of significant correlations between subtests on the Youth Fitness Test, some question of the sensitivity of the various subtests might be raised. The writer believes that further experimentation with isometric training should be considered which would employ the use of dynomometers, ergometers, cardiotachometers, gasometers, etc. Such measurement might well be done to further validate the Youth Fitness Test.

In conclusion, it appears that isometric training will develop the various attributes of physical fitness. Utilization of isometric effort for this purpose might possibly enable more students to experience the rewards of a physically fit body.

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APPENDIX A

THE EXPERIMENTAL PROGRAM

The experimental programs were comprised of the following ten basic exercises. It should be noted that a definite attempt was made to involve the same muscle groups in each of the programs, and that the same terminology is used to name the corresponding efforts.

Supine Press

Weight Exercise

Isometric Exercise

Figure 1

Procedure: Grasp the bar with a pronated grip. Extend arms fully, raising the bar vertically, lower slowly back to rest on the chest. Repeat six to eight times.

Procedure: Grasp the bar with a pronated grip. Attempt to extend arms using maximal effort. Maintain the contraction for six to eight seconds.

Muscles most involved: Triceps (8), Pectoralis Major (19), Coracobrachialis (17), Short Head of Biceps (15), and Anterior Deltoid (7). (The numbers refer to the charts of muscles in Appedix D)

Prone Horizontal Arm Lift

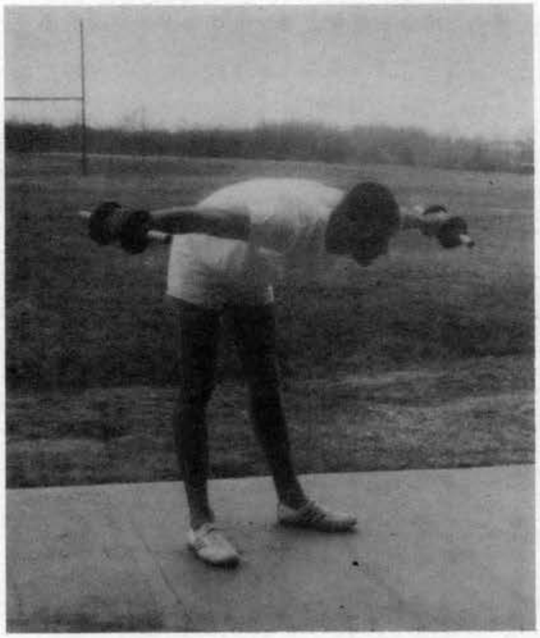
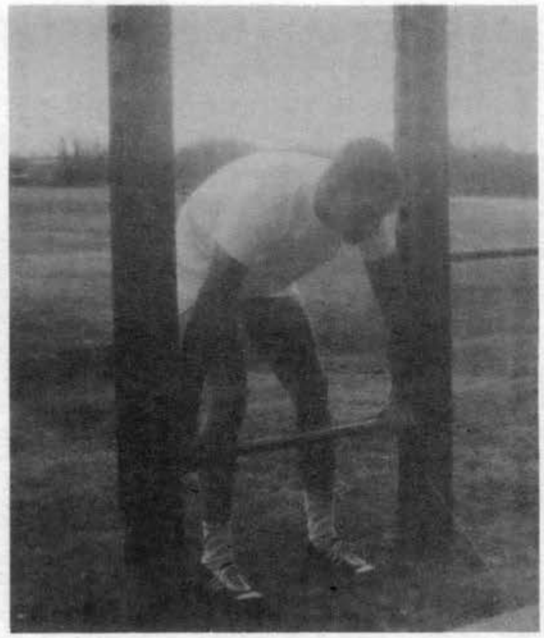
Weight Exercise	Isometric Exercise
	

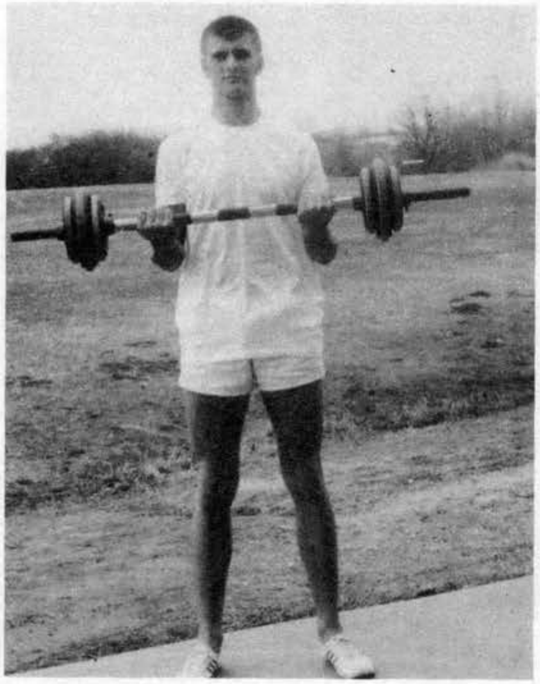
Figure 2

Procedure: Grasp the dumbbells with palms facing inward. With elbows locked swing the dumbbells out and up slowly as far as possible, lower and repeat six to eight times. Hold upper body parallel to floor.	Procedure: Grasp the bar with a wide grip, elbows locked. Attempt to bring the hands outward and behind the back while keeping the body parallel with the floor. Hold contraction six to eight seconds.

Muscles most involved: Posterior Deltoid (7), Lattismus Dorse (21), Teres Major (22), and Trapezius (10).

Two Arm Curl

Weight Exercise



Isometric Exercise

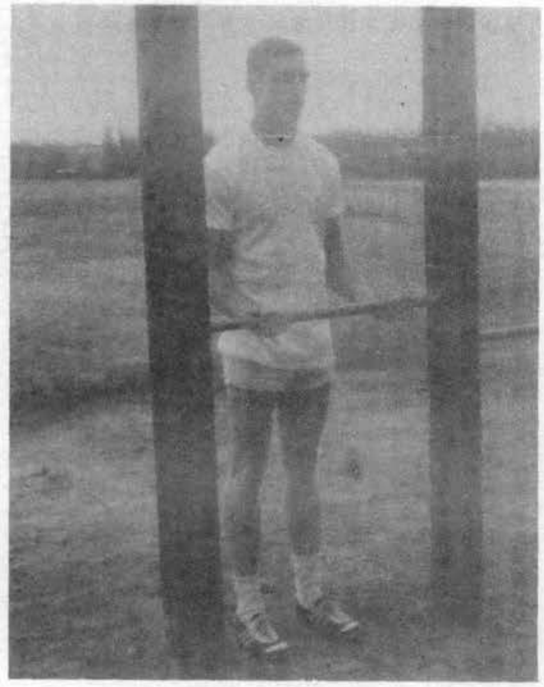


Figure 3

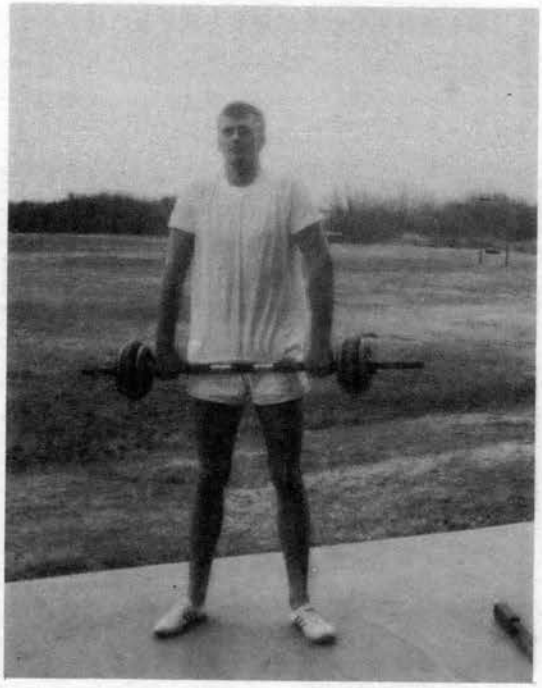
Procedure: Grasp the bar with a supinated grip, hold back and upper arms rigid, bend elbows until the bar touches the shoulders, and lower the bar slowly until arms are fully extended. Repeat six to eight times.

Procedure: Grasp the bar with a supinated grip, hold back and legs straight, and exert maximal effort toward raising the bar toward the chin. Hold the contraction for six to eight seconds.

Muscles most involved: Biceps (15) and Brachialis (16).

Shoulder Shrug

Weight Exercise



Isometric Exercise

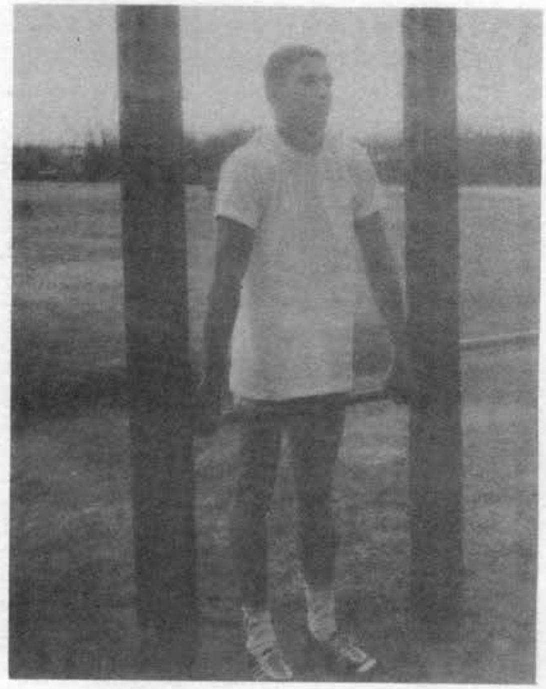


Figure 4

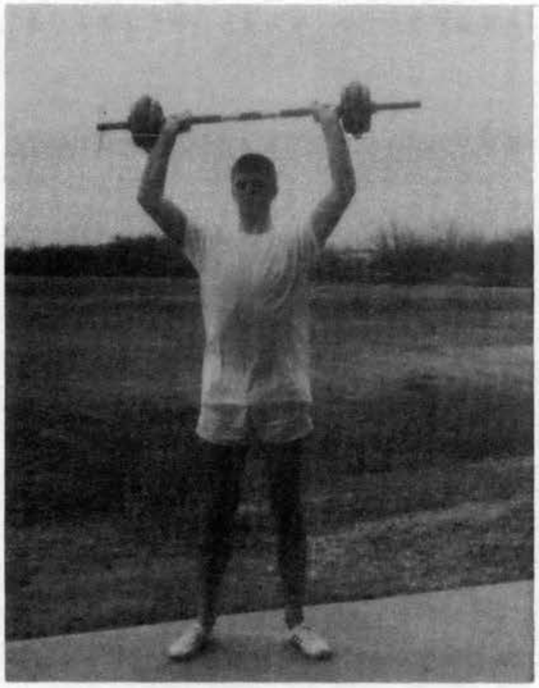
Procedure: Grasp the bar with a wide prone grip. Keeping the back, legs, and arms straight shrug shoulders as high as possible. Slowly lower them and repeat six to eight times.

Procedure: Grasp the bar with a wide prone grip with back, legs, and arms stright attempt to raise the shoulders. Hold maximal tension for six to eight seconds.

Muscles most involved: Platysma (29) and Trapezius (10).

Posterior Military Press

Weight Exercise



Isometric Exercise

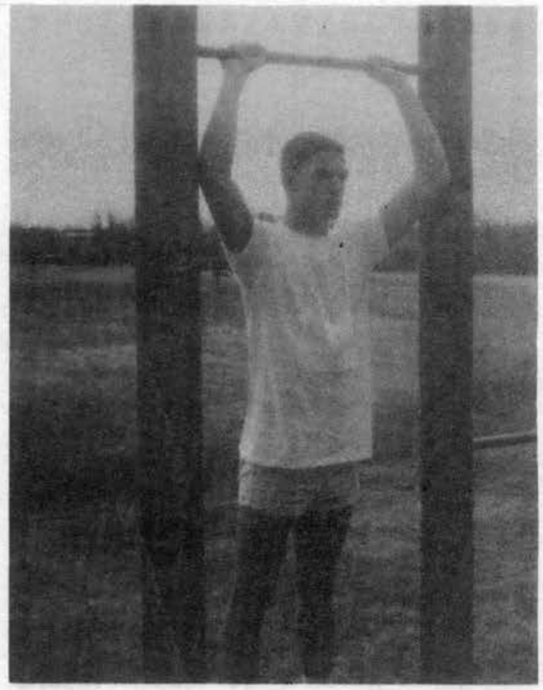


Figure 5

Procedure: Grasp bar with a shoulder-wide pronated grip, raise the bar vertically until arms are fully extended, lower slowly until the bar again rests on the shoulders. Repeat six to eight times.

Procedure: Grasp bar with a shoulder-wide pronated grip, keep the back and legs straight, attempt to raise the bar exerting maximal effort. Hold the contraction for six to eight seconds.

Muscles most involved: Triceps (8), Deltoid (7), Trapezius (10), and Serratus Anterior (18).

Leg Press

Weight Exercise

Isometric Exercise

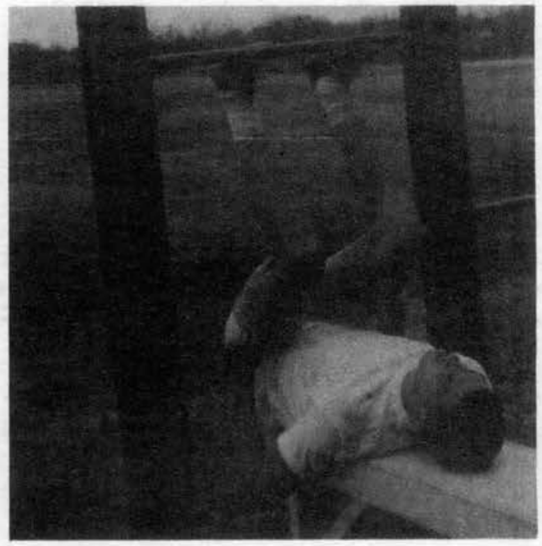


Figure 6

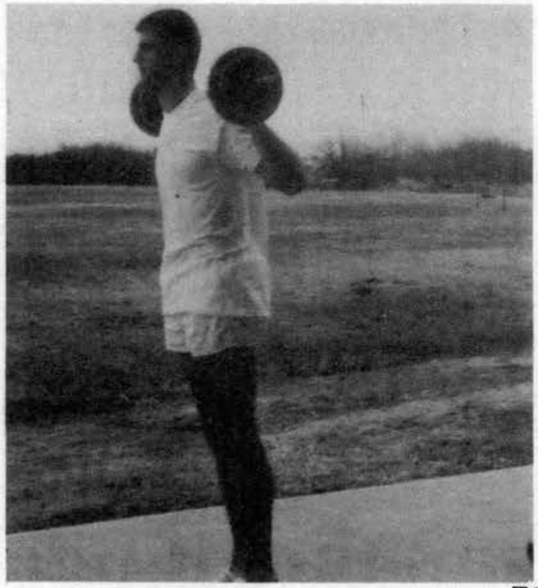
Procedure: With bar placed confortably on bottoms of feet, fully extend legs, lower bar slowly until legs are flexed no more than ninety degrees. Repeat six to eight times.

Procedure: Assume supine position with trunk directly underneath the bar. Attempt to extend the legs against the resistance of the bar. Exert maximal effort for six to eight seconds.

Muscles most involved: Gluteur Maximus (5), Semitendinosus (11), Semimembranosus (12), Biceps Femoris (13), Rectus Femoris (23), Vastus Medialis (26), Vastus Lateralis (24), Vastus Intermedius (25), Gastrocnemius (14), and Soleus (27).

Toe Rise

Weight Exercise



Isometric Exercise

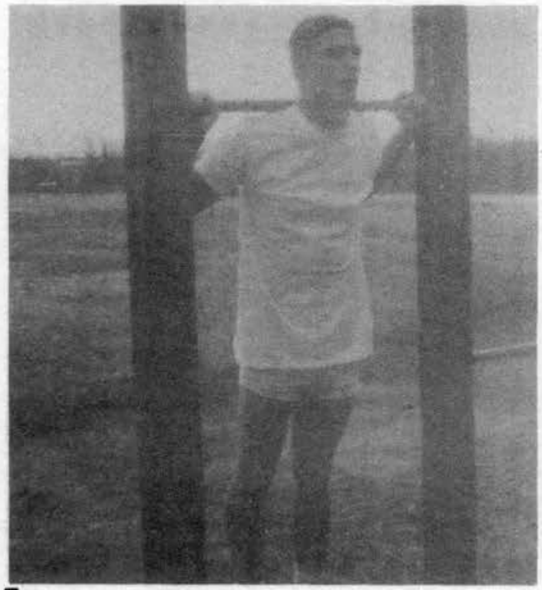


Figure 7

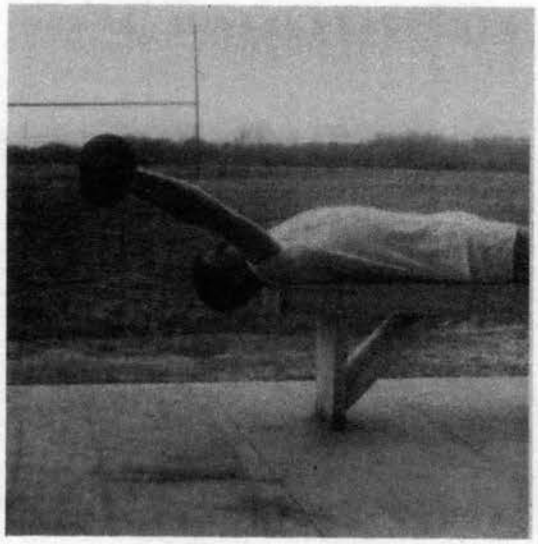
Procedure: With resistance on shoulders and balls of feet on mat or block, rise as high as possible on toes, lower heels slowly. Repeat six to eight times.

Procedure: Stand under bar with block or mat under balls of feet. Raise heels off floor and maintain maximal exertion against resistance for six to eight reconds.

Muscles most involved: Gastrocnemius (14), and Soleus (27).

Straight Arm Pullover

Weight Exercise



Isometric Exercise

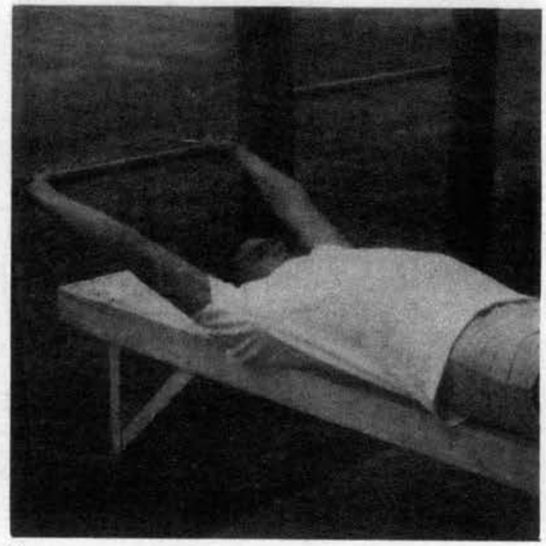


Figure 8

Procedure: Grasp the bar with hands in a prone grip about shoulder width. Elevate the bar and bring back over the head to floor and back to waist keeping the arms straight. Repeat six to eight times.

Procedure: Grasp the bar palms up at shoulder width behind the head. With maximal exertion attempt to pull the bar up and forward across the body. Hold tension for six to eight seconds.

Muscles most involved: Pectoralis Major (19), Latissmus Dorsi (21), Serratus Anterior (18), and Pectoralis Minor (20).

Supine Horizontal Arm Lift

Weight Exercise

Figure 9

Procedure: Grasp the dumbbells with a supinated grip, arms extended. Bring the dumbbells together over the chest and slowly lower to floor. Repeat six to eight times.

Isometric Exercise

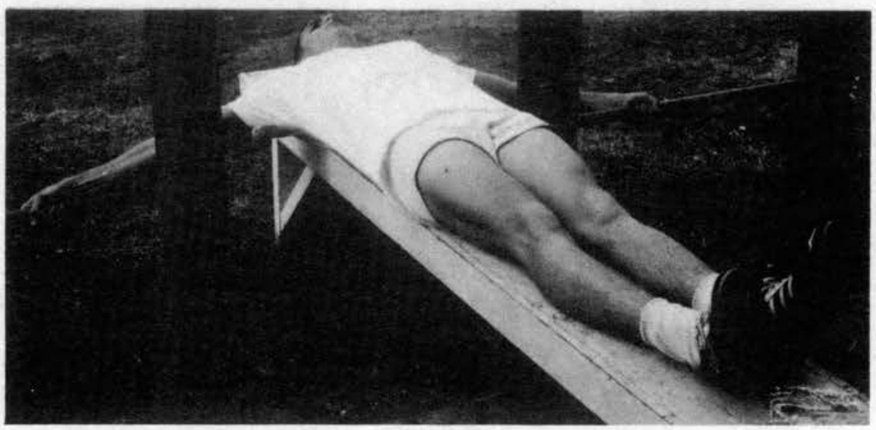


Figure 9

Procedure: Grasp the bar with a supinated grip, arms extended. Keeping the elbows locked, exert maximal effort to bring the hands together over the chest. Hold the contraction for six to eight seconds.

Muscles most involved: Anterior Deltoid (7), Pectoralis Major (19), Coracobrachialis (17), and Serratus Anterior (18).

Situps

Weight Exercise

Figure 10

Procedure: Hold weight on head or chest and curl body forward to sitting position. Keep legs as straight as possible. Assistance in keeping the feet on the floor is necessary. Repeat six to eight times.

Isometric Exercise

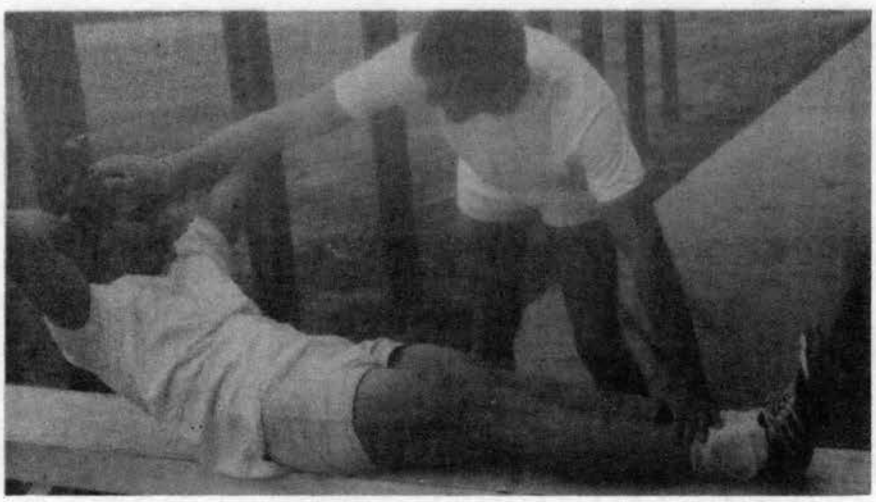


Figure 10

Procedure: With feet held in place curl body thirty to forty-five degrees toward sitting position against resistance. Hold maximal contraction in this position for six to eight seconds.

Muscles most involved: Rectus Abdominis (1), External Oblique (2), Internal Oblique (3), and Transversus Abdominis (4).

APPENDIX B

THE YOUTH FITNESS TEST

The seven subtests which are administered to boys are pullups, situps, standing broad jump, shuttle run, fifty-yard dash, softball throw, and 600 yard run-walk.

The Pullup Test

The pullup test consists of grasping a bar, which is beyond touch of the standing participant, with a prone grip of both hands the participant then raises his body until the chin can be placed over the bar. When this movement is completed the body is lowered to starting position. The objective is repeat this feat as many times as possible without swinging the body or bending the legs or body.

This aspect of the battery measures strength of Biceps, Trapezius, and Lattissmus Dorsi muscles.

The actual number of pullups completed properly is the participants score.

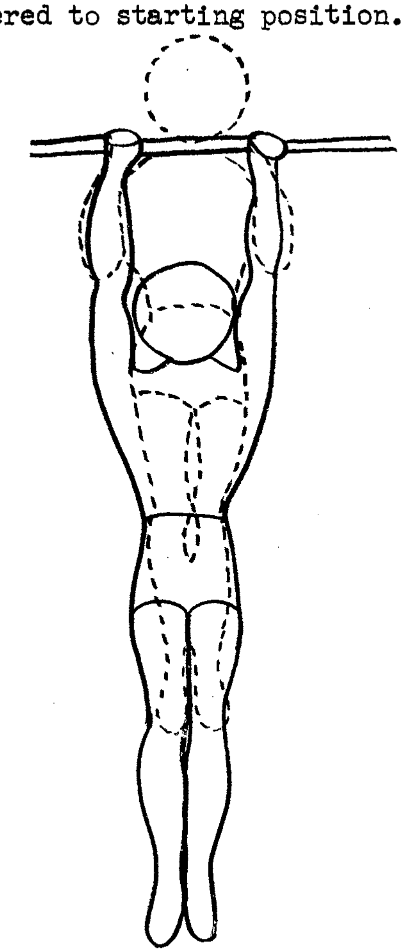


Figure 11.

The Situp Test

The situp test consists of an exercise in which the participant starts from a supine position on a floor or mat with the fingers interlaced behind the head, elbows on floor or mat, and legs extended with feet about two feet apart. The test manual advocates having a partner hold the participants ankles to the floor. From this position he bends straight forward until the right elbow is brought into contact with the left knee. He then returns to the starting position and repeats the exercise, this time bringing the left elbow in contact with the right knee. Throughout the remainder of the test, the participant alternates elbow-to-knee contact with each successive repetition. The fingers must remain in contact behind the head and the legs as straight as possible throughout the complete movement.

There is a maximum of one hundred repetitions placed on this test. The number of repetitions successfully completed is recorded as the student's score.

This test measures strength and endurance of the Internal Oblique, Transversus Abdominis, and Rectus Abdominis muscles.

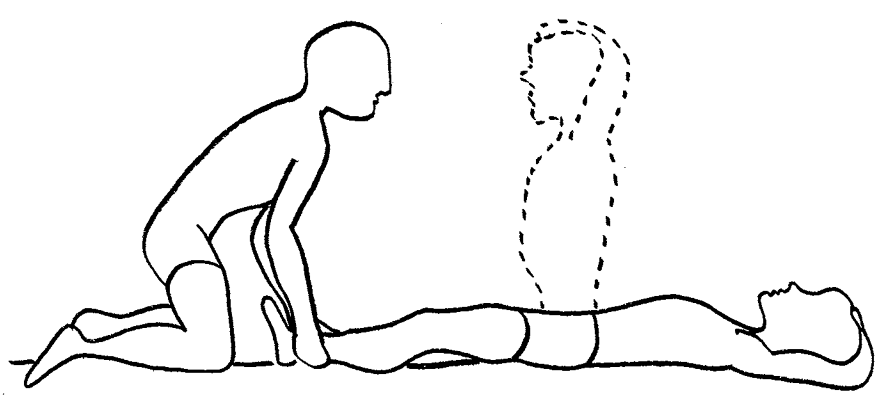


Figure 12.

The Shuttle Run

The shuttle run is a test against time in which the participant remains behind a restraining line until given the starting signal. Upon receiving such signal, he runs to a parallel restraining line and picks up one of the two small blocks of wood (2" X 2" x 4") which had been placed there beforehand, and returns to his starting point. He then places the block of wood there and returns for the second block. Time is measured from the beginning signal to the participant's crossing the starting line with the second block of wood.

The manual recommends allowing two trials and recording the better effort to the nearest one-tenth second.

This test measures leg strength and coordination as manifested in speed and agility.

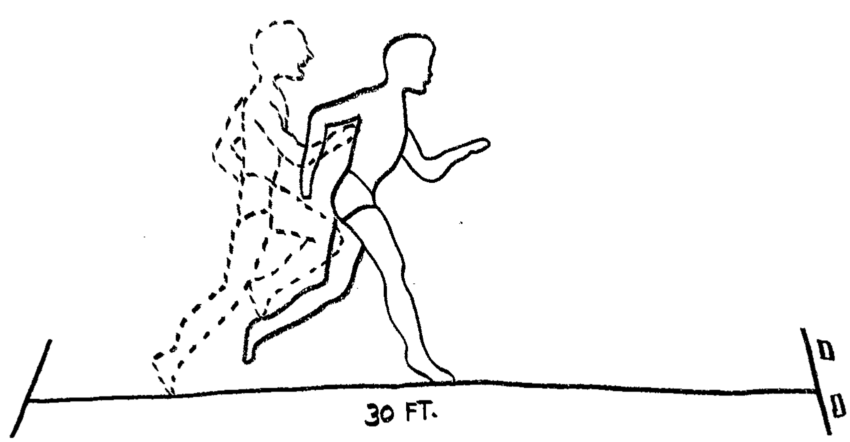


Figure 13.

Standing Broad Jump

The standing broad jump is a test in which the participant plants both feet in a stationary position behind the starting line and without moving the feet from that position jumps for distance in a direction perpendicular to the take-off line. It is permissible, even advisable, for the participant to bend his body and legs and to swing his arms to assist in executing such test.

The amnual advocates allowing three trials for each subject and recording the best of the three.

This test measures strength of the Vastus Lateralis, Vastus Intermedius, Rectus Femoris, Vastus Medialis, Gastrocnemius, Soleus, and Gluteus Maximus muscles, and muscle coordination.

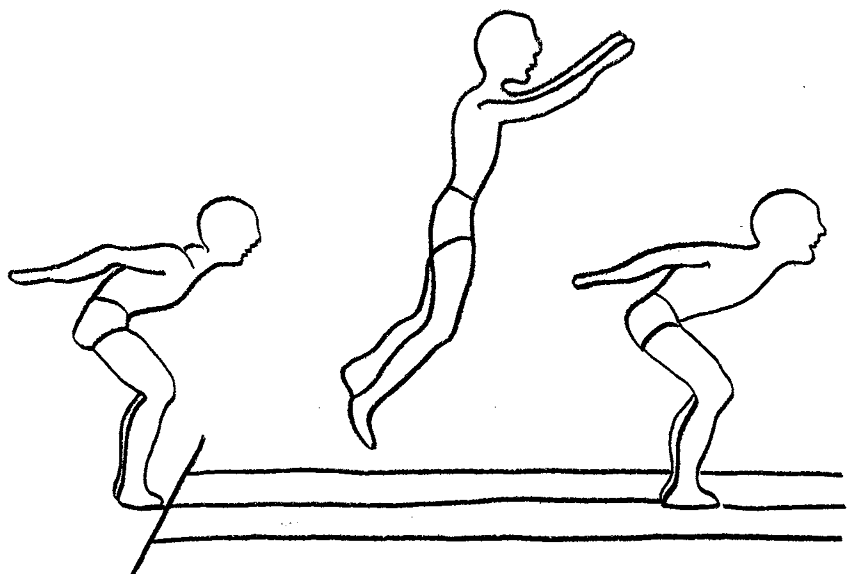


Figure 14.

The Fifty-yard Dash

The fifty-yard dash is a test of running speed in that the participant is required to run against time for the length of the race. There are no obstacles to overcome and no manuvers to accomplish.

The students score is the number of seconds to the nearest tenth that it takes for the student to run the dash.

The Softball Throw

The softball throw for distance is a test in which a regulation size softball is thrown from between two restraining lines in an effort to achieve maximal distance. Three throws for each participant are allowed with only the best one recorded for his effort. According to the rules cited by the manual, only an overhand throw may be used.

The student's score is recorded to the nearest foot of actual distance thrown.

This test measures coordination, speed, and strength of the various arm and chest muscles.

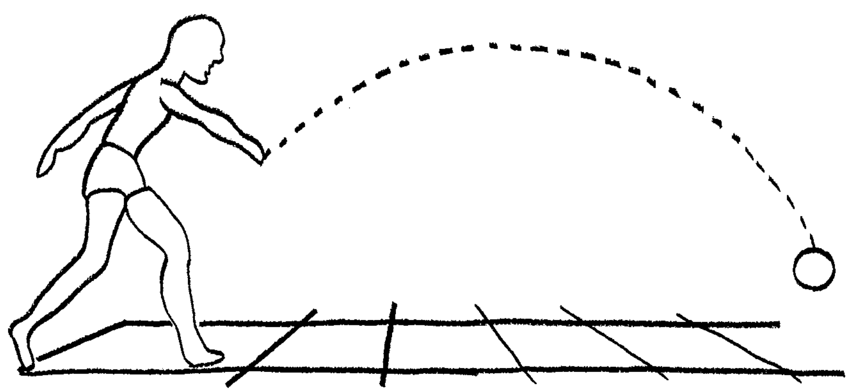


Figure 15.

The 600 Yard Run

In the 600 yard run-walk the objective is to cover the distance in the least time possible even though some participants may not be able to run the complete distance. Running may be interspersed with walking, but the subjects should be encouraged to exert maximal effort.

The course should be laid out around an oval or circular track to prevent the excessive physical demands of maneuvering corners.

This test of endurance is scored by recording the time in minutes and seconds that it takes the subject to cover the 600 yard distance.

APPENDIX C

INITIAL STATUSES OF HEIGHT, WEIGHT, AND AGE

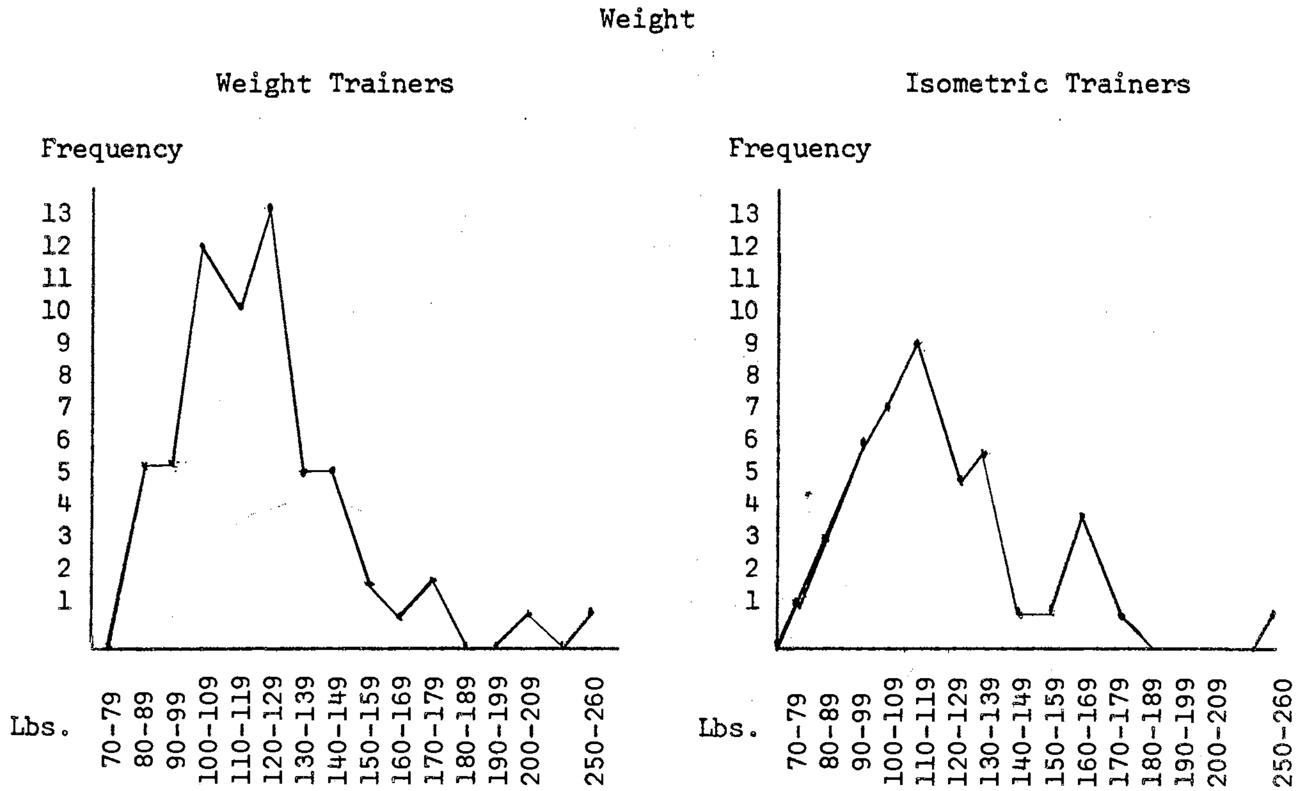


Figure 16

Height

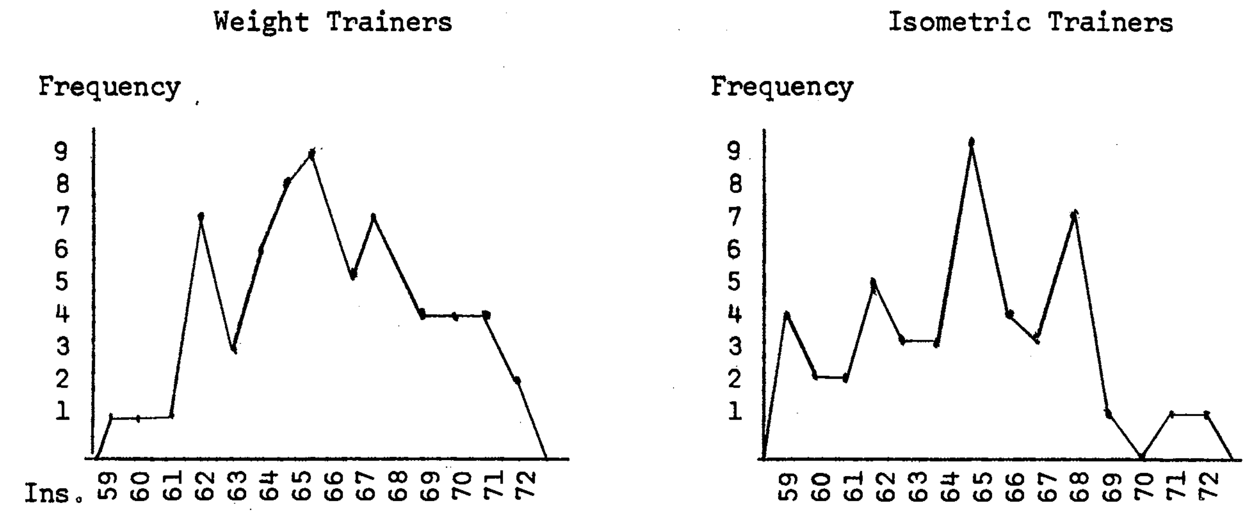


Figure 17

Age

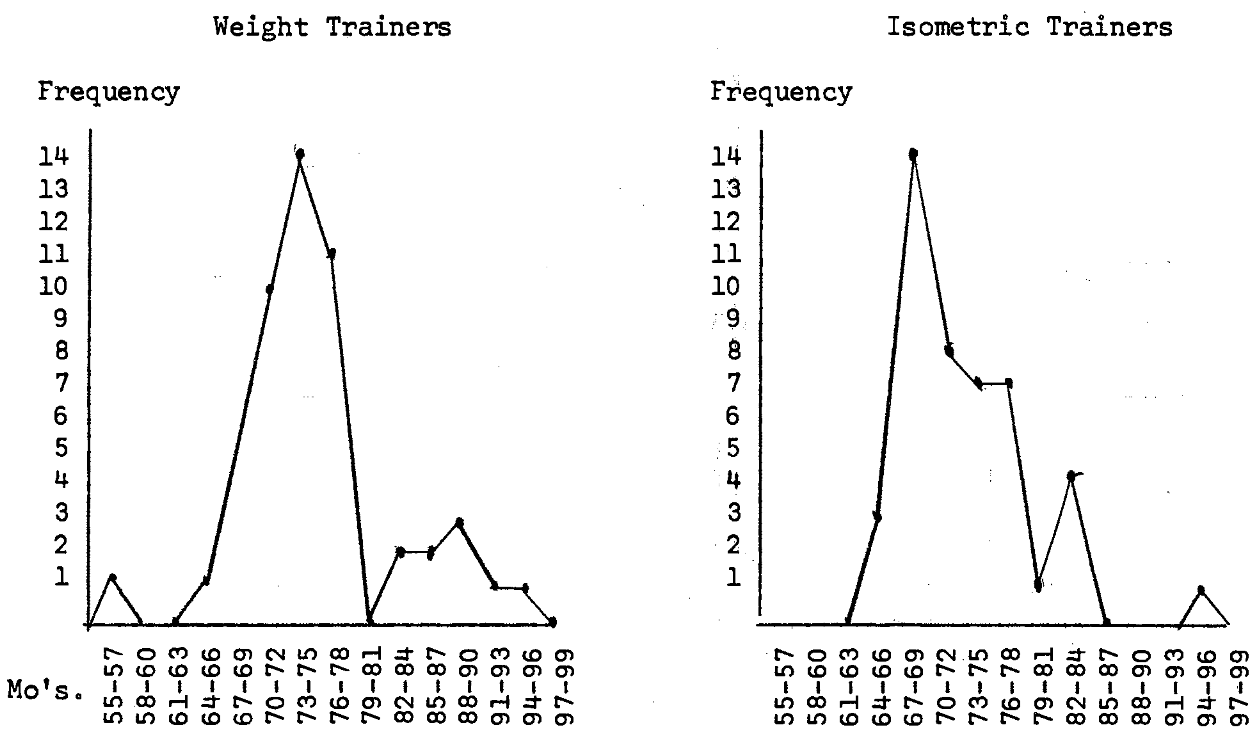


Figure 18

APPENDIX D

CHART OF SKELETAL MUSCLES

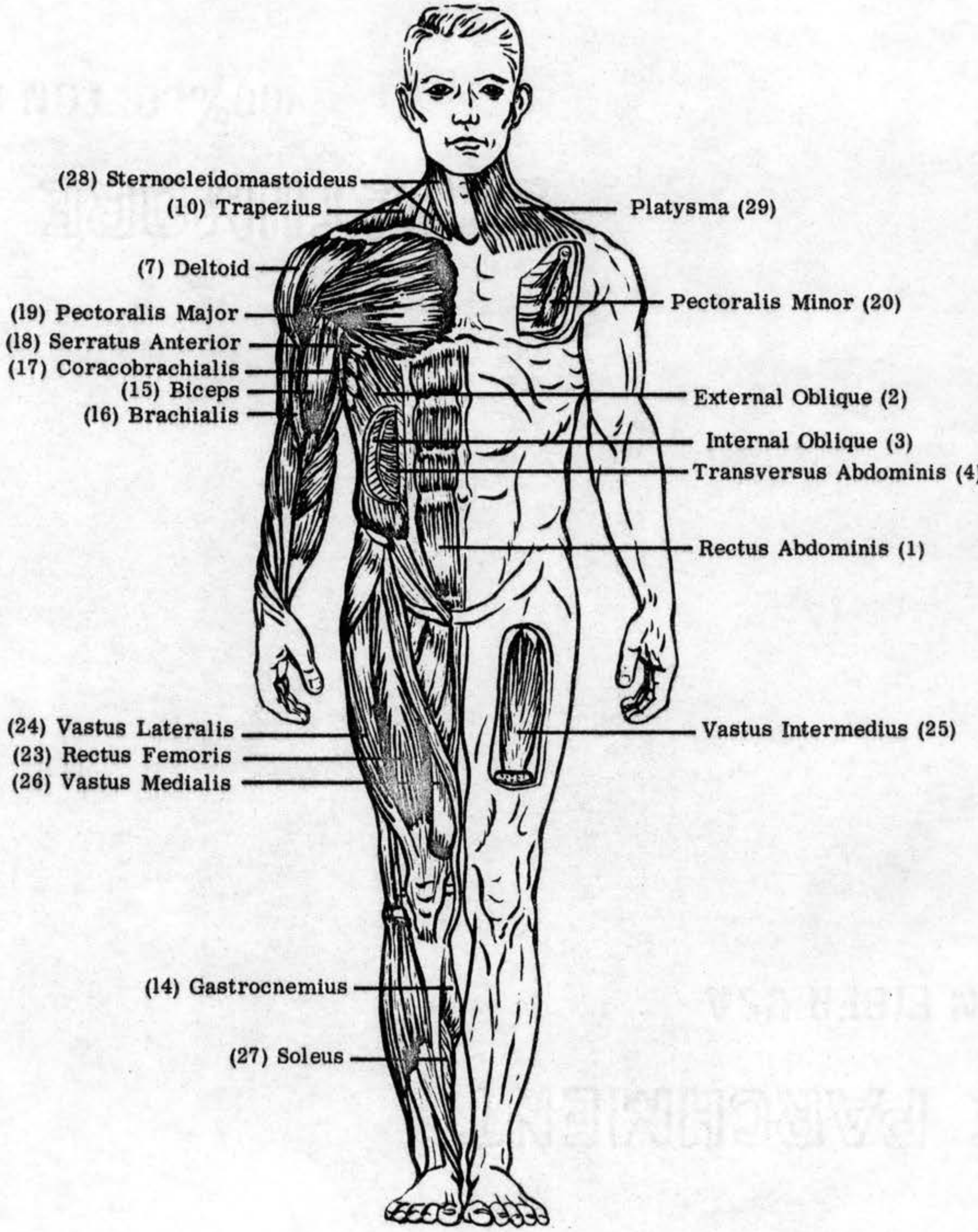


Figure 19

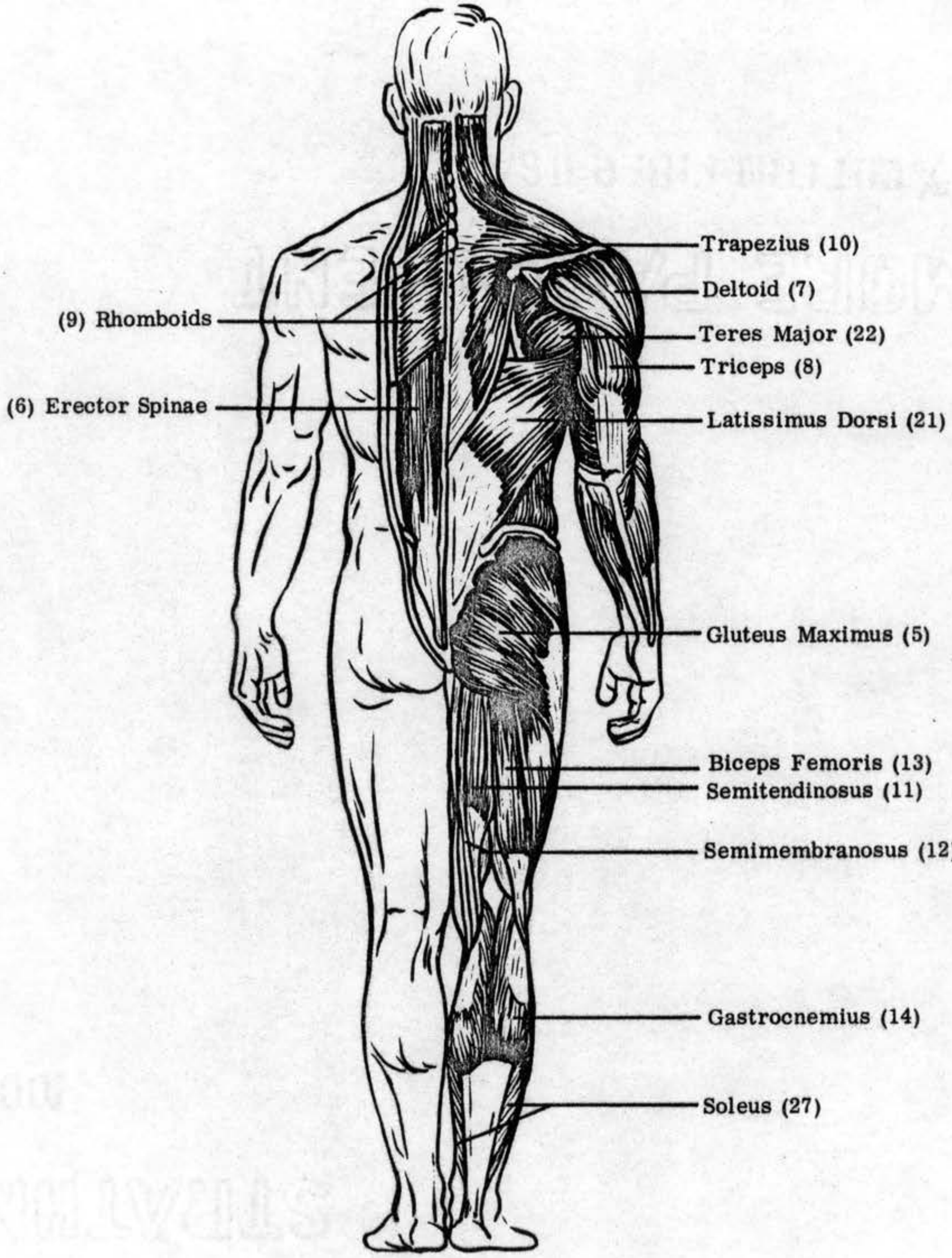


Figure 19 (continued)

APPENDIX E

FOLLOW-UP INSTRUMENT

Name ______________________ Program ______________________

First let me express my appreciation to you for your participation in the comparative study of isometric and weight training during the fall semester at your Junior High School.

The results of that comparison are being forwarded to your physical education instructor to aid in the planning of future programs for that school and other schools of the Muskogee system.

An additional aspect of the comparison is to determine the degree with which participants continued the training programs beyond school requirements. Your checking the appropriate items below and returning this sheet to your instructor will be highly appreciated and will help determine the relative merits of the training programs.

Thanks for your cooperation.

Sincerely,

signed

Merrill Redemer
Oklahoma State University

Of what value was the training program to you?
Much value Some value Little value No value

Check the following effects (if any) that are applicable to you as a result of the program:

Feel better	Have greater stamina
Feel Stronger	Have better posture
Physically more active	Have less sickness
Greater appreciation for P.E.	Better physique

Other benefits Specify ______________________________

____

How often have you practiced the exercise routine since it is no longer required by the school?

Three times weekly　　Twice weekly　　Once weekly

Not regularly　　None

For what primary reason did you continue (not continue the activity?____

____

Would you like to see a program similar to the one in which you participated become a regular part of physical education activity?　　Yes　　No

VITA

Merrill Dwane Redemer

Candidate for the Degree of

Doctor of Education

Title: A COMPARATIVE STUDY OF THE EFFECTS OF ISOMETRIC TRAINING ON THE PHYSICAL FITNESS OF MALE YOUTH

Major Field: Education Administration

Biographical:

Personal Data: Born near Forgan, Oklahoma, December 19, 1932, the son of Frank O. and Mary A. Redemer.

Education: Attended elementary schools at Forgan and Beaver, Oklahoma; graduated from Beaver High School in 1950; received the Bachelor of Arts degree from Panhandle A & M College, Goodwell, Oklahoma, in May, 1954 with a degree in English; received the Master of Science degree from Oklahoma State University in August, 1960 with a major in educational administration.

Professional Experience: Served in U. S. Army from 1954 to 1956 as cadre and instructor; appointed football coach and speech teacher at Texhoma High School, Texhoma, Oklahoma, 1956; assumed counseling duties there in 1958; appointed superintendent of schools at Centralia, Oklahoma in 1960; appointed superintendent of schools at Bluejacket, Oklahoma in 1961; served as graduate assistant for one semester at Oklahoma State University in 1963; served as research assistant since January 1964.